An Assessment of the LNAPL Recovery Operation, Mission Valley Terminal and Off-Site Area, San Diego, California

Submitted to the City of San Diego MVT Working Group

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Introduction

The Time Schedule Order (TSO) R9-2002-0042 issued by the California Regional Water Quality Control Board in March 2002 states that Kinder-Morgan Energy Partners (K-M) and others must submit (page 4):

> "*an updated contingency plan and a proposal for milestone cleanup dates for the restoration of water quality in the portion of the Mission San Diego Hydrologic subarea proposed for the development by the City of San Diego for municipal use and for the cleanup of all off-site pollution.*"

Because of the Arbitration finding of Judy Robert Altman (March 21, 2003), K-M are to undertake the cleanup of the MVT property and the off-site area beneath the QualComm Stadium Parking Lot, which is property owned by the City of San Diego.

While the TSO states that K-M must "*clean up all off-site pollution*", the Final Summary Report of January 30, 2004 does not provide for cleanup of the off-site area below the Mission Valley Terminal (MVT) by June 2005. K-M and its consultants, LFR Levine-Fricke (LFR), have provided the following schedule of LNAPL recovery and site cleanup dates (LFR, 2004, Table 1):

1. Reduce the measurable thickness of LNAPL in the off-site area to <0.01 ft by January 2007; and
2. Complete off-site remediation and containment of the LNAPL and take no further action by 2015 to 2034.

These schedule goals are focused on the first requirement of paragraph D of the TSO, i.e., "*restoration of water quality*" at a pace that is calculated to be sufficiently inexpensive to meet the TSO. While LFR might call this "*a proactive and logical approach toward accomplishing the remedial objectives and TSO goals*", it is an approach that intends to suffice the regulatory requirement at least cost for K-M.

As recently as July 2003, LFR (2003a, page 5) indicated that it would "[r]emediate off-site area for drinking water use by 2010." Therefore, the K-M strategy appears to have been postponed by at least five years. On the other hand, the City of San Diego has made clear its' needs for use of the Mission Valley Aquifer in 2005 for redevelopment, including a two MGD Ground-Water Supply System to provide drinking water to approximately 4,000 homes (City of San Diego, February 2, 2004).

The second part of the TSO requirement is not addressed with any special effort, hence LFR write (p.28): "*Complete removal of all residual LNAPL from the off-site area is not an objective of the proposed remedial measures, nor is it necessary to accomplish the remedial goals.*" This appears to be a repudiation of the Order. They further note (p. 31) that LNAPL thickness measurements will become non-detectable by January 2007 on the basis of historical trends. Their approach to the 'cleanup' demand is to continue the ground-water and the LNAPL extraction from the recovery wells and to expand the soil-vapor extraction (SVE) system.

Critique of the Final Summary Report

A large number of uncertainties undermine the schedule identified in the Final Summary Report. These include the following issues that address both the characterization of the Site (issues 1-4) and the current remediation strategy (issues 5-7):

1. LFR assumes that there is no longer a **continued migration of LNAPL** down the valley from the Terminal and moving off-site beneath San Diego Mission Road is zero. LFR must provide redundant and complementary data to indicate that LNAPL migration from the MVT across Mission Road has ceased.

2. As noted by Johnson and Eggers (2004, p. 3), "the **vertical distribution of residual LNAPL in soils** receives little attention in the [Remediation System Technical Evaluation Report] ... and it is unclear how well the vertical distribution of residual LNAPL is understood." The LNAPL saturation profiles identified in Tables D-7 and D-8 of the Final Summary Report, appear to be very low – no saturation exceeds 3% – given the recent observations of mobile LNAPL in wells such as R-11 and the likelihood that LNAPL trapping beneath the Parking Lot was partly caused by the LNAPL encountering the fine-grained sediments of Mission Valley as it exited the Murphy Creek paleochannel. N.B. The City of San Diego MVT Working Group urged the Regional Water Quality Control Board to order such measurement by LFR (See "Statement of Remedial Criteria", page 12, item nr. 3).

3. The lack of measured vertical distributions of LNAPL beneath the Parking Lot means that estimates of the **off-site LNAPL volume** are very approximate. LFR apparently has tried to estimate this volume in Appendix C of the Final Summary Report and obtained an average mass estimate of 631,000 lbs of LNAPL, which is approximately 100,000 gallons of which 1% is benzene and 0.2% is MTBE. However, LFR attempted doing this by correlating CPT-LIF logs with soil-chemical samples from boreholes that may have been as far apart as 20 feet. Not surprisingly, because the CPT-LIF tool only measures LNAPL within one cm of the tool, the correlation between CPT-LIF and soil samples – as shown in Figure C-1 – was completely random. Such a result should have been expected given the heterogeneity of the soils and the short penetration distance of the LIF tool. The City's Working Group continues to recommend continuous coring of the LNAPL zone in at least ten sites in the Parking Lot to establish more reliable vertical profiles.

4. The **appearance of LNAPL in R-11** (page C-5), which is well outside the zone of residual LNAPL shown in Figure 4 of the July 2003 LFR report on the LNAPL distribution (LFR, 2003a) raises some fundamental questions about the reliability of the CPT-LIF surveys conducted and LFR's interpretation of the acquired data. This occurrence suggests that R-11 may be situated in a continuation of the paleochannel that so effectively moved LNAPL from the K-M manifold to the QualComm Parking Lot. What are needed are an exhaustive CPT survey of the LNAPL zone and the subsequent creation of a geological model of the Site that identifies paleochannels formed by the delta of the ancestral Murphy Creek as it discharged to Mission Valley. At present, the remediation program seems to be uncoupled from any appreciation of sedimentary processes and depositional models. A revision of the LNAPL zone map is quite obviously required if LNAPL removal is to be successfully undertaken.

5. Johnson and Eggers (2004, p.7) argued that the **decommissioning of the air sparging system** may not have been wise because Professor Johnson in particular believes in the importance of oxidation as a long-term remedial goal. LFR commented during conference call of February 10th that it believed that the

oxidation of the contaminated soils beneath the Stadium Parking Lot was better achieved by means other than in-situ air sparging (IAS), e.g., oxygen-release compounds (ORC). Professor Johnson demurred (see page 7 of Johnson and Eggers). Without a quantitative model of the distribution of LNAPL across the Parking Lot, including its distribution with depth, the efficacy of using ORC is questionable because it can only cause oxidation in the saturated zone, into which it is injected, whereas IAS introduces oxygen into the saturated (or ground-water) zone and causes the oxygen to rise into the unsaturated (or vadose zone). Because LFR estimates (Final Summary Report, page D-7) that the equilibrium dissolved-phase concentrations for benzene in contact with LNAPL is approximately 40,000 ppb and the California MCL is 1 ppb, the need for massive oxidation of the LNAPL zone to reduce the mass fluxes should be obvious, as is the need for LNAPL removal.

6. If the number of **pore volume equivalents** (PVE) that are required to complete the SVE project is so uncertain that it may be from 200 to 5,000 (page 8, LFR, 2004), then it is incumbent on K-M to present a Work Plan to determine the number of PVEs by pilot testing. In essence, LFR have committed K-M to what is known as "all-up" testing without the benefit of progressing from pilot testing on site to full-scale remediation and thus incorporating lessons learned along the way. The heterogeneity of the soils beneath the Parking Lot will likely lead to significant by-passing of LNAPL in lower permeability units by air flow to soil-vapor extraction wells and the subsequent decreased efficiency in the soil-vapor extraction process (see Johnson et al., 1990).

7. A two million gallon-per-day ground-water desalting project is deemed by the City of San Diego MVT Working Group to be technically viable and economically attractive for the Stadium area of Mission Valley (City of San Diego, March 2004). Such as system would provide water for approximately 4,000 homes. Consequently, the **mass flux of dissolved MTBE and benzene** from the LNAPL zone would be distributed to perhaps three wells pumping at a rate of 500-750 gpm each. Because of the very low residual saturations ascribed to 'Soil Columns 1 and 2' in Table D-7 and D-8 and mentioned above, it is

unclear from the Final Summary Report what the effect of such ground-water extraction would be on the mass flux calculations relative to the target values calculated if higher LNAPL saturations were in fact measured during the recommended field work proposed in the City Working Group's Statement of Remedial Criteria. The higher specific discharge caused by the extraction of a 1400 gpm system might off-set an increase in measured saturations, however it should be clear that the dilution and attenuation of MTBE and benzene that might occur would amount to using the soils beneath the Parking Lot as an attenuation zone for gasoline that migrated 2,000 ft from the K-M manifold. Such use would be at odds with the City's intention to use the same soils for ground-water supply purposes and perhaps eventually for imported water recharge.

Estimating the LNAPL Volume

LFR provide an average estimate of 631,000 lbs of gasoline (page C-6), which is equivalent to approximately 100,000 gallons. This volume may be compared with the 44,000 gallons recovered by SVE operations until the end of September 2003. The use of units of mass (i.e., lbs) rather than of volume (i.e., gallons) arises from the measurement of gasoline in soil cores in terms of mg of gasoline per kilogram of soil. The conversion from units of mass to those of volume is obtained by using the approximate conversion factor of 6.2 lbs of gasoline per gallon. However, the soil cores are spread far apart and are not necessarily close to the CPT-LIF logged boreholes that provide detailed soil texture and approximate hydrocarbon measurements. As noted above, the correlation between soil cores and LIF estimates of gasoline volume were poor.

Therefore, an alternative approach is to assign reasonable average LNAPL saturations to the vadose (2%) and saturated (4%) portions of the LNAPL smear zone and multiply by the contaminated volume and estimated porosity. INTERA used the LIF response areas and thicknesses as given in Appendix C of the Final Summary Report estimate the volume of contaminated sediments. The dry bulk densities for each of the sediment types given in the report were used to estimate porosities. Using this approach, INTERA has estimated a residual NAPL volume in the Off-Site Source Area of some 70,000 gallons. This estimate excludes the volume of sediments outside the area of soil contamination identified leading down to and past well R-11, where accumulations of NAPL have been measured. Therefore, the LFR estimate of ~100,000 gallons appears reasonable.

A third way of estimating LNAPL volumes – and the most reliable approach when coupled with soil cores for vertical definition – is to use the partitioning interwell tracer test or PITT that was developed and patented by the University of Texas at Austin and INTERA (Jin et al., 1995). This method has been used over 40 times in the last ten years to measure the interwell volumes of NAPL at sites across the USA, in Europe and in Australia. It involves the injection of a suite of tracers that have varying propensities to partition into and out of gasoline. The measurement of the tracer signals at the extraction well(s) allows one to estimate the volume of NAPL between the two wells and the average interwell LNAPL saturation. The tracers used in ground-water-zone PITTs are usually alcohols, whereas gas tracers are used in vadose-zone PITTs. This process has twice been applied by INTERA at LNAPL sites, including the former Gulf Refinery near Cincinnati, Ohio (ground-water-zone PITT) and at the US Department of Energy Pantex plant near Amarillo, Texas, where toluene LNAPL was detected in the vadose zone perched thirty feet below ground surface. INTERA itself has conducted 22 such PITTs since 1995, all but two at chlorinated solvent sites. Coincidently, LFR personnel based in Florida have conducted PITTs under license from INTERA in California and in Florida (no license granted) also at chlorinated solvent sites.

The particular advantage of using a PITT in the present context is that it allows large zones of the subsurface – both the vadose and ground-water zones – to be accurately tested in a manner that could only otherwise be tested by a prohibitively large number of soil samples. Therefore, the hydrogeologist's pumping test is to the laboratory permeameter test what the PITT is to the chemical analysis of soil cores. Just as hydrogeologists realized in the 1940s that water-supply wells (and later capture zones) required interwell hydraulic conductivity tests rather than testing a few small soil samples in a permeameter, so to has it become desirable to measure the interwell NAPL volume using PITTs. Vertical discretization of the LNAPL zone would be measured by a continuous soil core, probably obtained with a cohesionless soil sampler.

Rates of Recovery of LNAPL from Alluvium

It is well established (e.g., Johnson et al., 1990) that the recovery of LNAPL from alluvium progresses rapidly at first and then declines to a much slower, perhaps even asymptotic rate. It is most likely that the early rapid rate of extraction reflects the recovery of LNAPL from the more permeable zones of the soil through which increasing amounts of air are pulled by soil vapor extraction wells and of water by ground-water extraction wells. Thus, the more permeable soils, e.g., sand lenses, are more rapidly cleansed of LNAPL and their permeability relative to the lower permeability silts is raised because the intrinsic permeability of the silts is lowered by the presence of LNAPL in the pores of the silt. This phenomenon, well known for over 40 years in the oil industry, is called 'by-passing'. It may account for the very long durations for MTBE and benzene to reach the target effective solubilities in the two soil columns studied in the LNAST simulations described in Section D of the Final Summary Report. LFR report that for 'Soil Column 2', in which more LNAPL is trapped in low-permeability silts, it may take 20 - 30 years for MTBE and 500 years for benzene to reach concentrations in ground water within the LNAPL zone that do not cause the mass flux targets to be exceeded, i.e., 5 g MTBE/day and 1 g benzene/day.

Such rates of decontamination are, of course, quite unacceptable when the City wishes to use its own land for purposes of ground-water supply development beginning in 2005. Therefore, methods of enhanced LNAPL recovery and enhanced bioremediation are required to accelerate site remediation. Enhanced LNAPL recovery would remove at least 90% of the remaining LNAPL and would allow much more rapid bioremediation of the remaining contamination through in-situ air sparging, nutrient injection and other methods of oxidizing the remaining gasoline. But bioremediation alone cannot remove the vast majority of the remaining 100,000 gallons or more; such the "heavy lifting" requires technologies that have been developed in the past ten years from those originally developed by the oil industry and known as enhanced oil recovery.

Enhancing LNAPL Recovery

A variety of technologies have been developed over the past few years to enhance the solubility or volatility of NAPLs such as gasoline or to promote their mobilization to extraction wells. These include methods of chemical flooding of the NAPL zone using alcohol ("cosolvent flooding") or surfactants and various thermal methods including steam flooding and various resistance heating methods. Typically these methods cost $100 to $300 per cubic yard of soil decontaminated.

The most energy intensive of these methods is steam flooding, which is presently being practiced at the US Naval Air Station North Island. This technology was first tested by Udell (1995) beneath the Motor Pool at the Lawrence Livermore National Laboratory in northern California. No independent (i.e., third-party) performance assessment of that flood was ever conducted. Udell (1995) indicates that there was some LNAPL remaining in low-permeability zones at the end of the steam flood. However, it is likely that over the course of the past ten years, the technology has improved to the point so that such by-passing can be minimized. The Federal Remediation Technologies Roundtable reports the cost of hot water or steam flushing/stripping remediation at $50 to $300 per cubic yard depending on site characteristics. Based on an estimated volume of contaminated sediments of some 38,600 cubic yards, the cost to remediate the source zone through the use of steam should fall within the range of 2 to 12 million dollars, with a likely cost of about $8 million. This technology is the most likely to remove the gasoline in the shortest possible period and therefore would be the most suitable.

Conclusions & Recommendations

The following conclusions are drawn:

1. The remaining volume of LNAPL trapped beneath the Parking Lot is uncertain but appears to be of the order of 100,000 gallons.

2. The spatial and vertical distributions of the LNAPL are poorly understood, however the LNAPL zone extends beyond R-11 and requires further definition in this area.

3. The rates of LNAPL recovery and site decontamination are uncertain because of points 1 and 2 above and further because there has been no pilot testing of soil vapor extraction to determine its effectiveness in removing LNAPL from within its estimated radius of influence.

4. **Without resolution of these uncertainties, meaningful milestone cleanup dates cannot be reliably established.**

Thus, significant uncertainties remain concerning the volume and spatial distribution of LNAPL beneath the QualComm Stadium Parking Lot. The milestone cleanup dates incorporated into LFR's Final Summary Report, including the 2010 milestone that LFR cited in July 2003, will not be met if LFR and K-M continue to follow the present remedial approach. The following recommendations are made to the Board:

(a) K-M should take steps to rent space in the critical area of the Parking Lot so that it is no longer hindered in gaining access to the ground surface above the LNAPL zone.

(b) K-M should map the spatial distribution of LNAPL beneath the Parking Lot using ten continuously sampled boreholes as suggested in the City of San Diego's Letter Report on Statement of Remedial Criteria (page 12, item 3).

(c) K-M should proceed without delay to install a barrier wall along Friars Road to cut off further LNAPL migration from the Terminal.

(d) K-M should conduct pilot testing of soil vapor extraction to determine the actual performance of their system.

(e) K-M should expand and re-commission their air sparging network and install soil vapor monitors.

(f) K-M should provide the Board with a plan to implement a three-month pilot test of enhanced LNAPL recovery and bioremediation beginning later this year in an area in which the LNAPL zone is well characterized.

(g) Shell and Texaco should proceed to remove their diesel plume from the Parking Lot by excavation as soon as possible.

References

California Regional Water Quality Control Board, March 13, 2002, Time Schedule Order (TSO) R9-2002-0042 issued by the San Diego Region.

City of San Diego MVT Working Group. February 2, 2004. Letter Report on Statement of Remedial Criteria.

City of San Diego Water Department, March 2004. Concept Study: Mission Valley Groundwater Desalting Project.

Federal Remediation Technologies Roundtable, January 2002, Screening Matrix and Reference Guide, Version 4.0 [http://www.frtr.gov/matrix2/section4/4_43.html#cost].

LFR, 2004 (January 30, 2004). Final Summary Report, Time Schedule Order R9-2002-0042. Mission Valley Terminal, San Diego CA. LFR Levine Fricke, Costa Mesa CA.

LFR, 2003b (December 12, 2003). Additional LNAPL Distribution and Lithologic Characterization. Mission Valley Terminal, San Diego CA. LFR Levine Fricke, Costa Mesa CA.

LFR, 2003a. (July 8, 2003). Remediation System Technical Evaluation Report. Mission Valley Terminal, San Diego CA. LFR Levine Fricke, Costa Mesa CA.

Jin, M., Delshad, M., Dwarakanath, V., McKinney, D.C., Pope, G.A.; Sepehrnoori, K., Tilburg, C.E., and Jackson, R.E. 1995. "Partitioning Tracer Test for Detection, Estimation and Remediation Performance Assessment of Subsurface Nonaqueous Phase Liquids"; Water Resources Research, 31(5), 1201-1211.

Johnson, P.C. and M.R. Eggers, January 13, 2004. Independent Technical Review Comments on the July 8, 2003 Remediation System Technical Evaluation Report. Mission Valley Terminal, San Diego CA.

Johnson, P.C., C.C. Stanley, M.W. Kemblowski, D.L. Byers, and J.D. Colthart., Spring 1990. A practical approach to the design, operation, and monitoring of in-situ soil-venting systems. Ground Water Monitoring & Remediation, pp. 166-168.

Udell, K.S., 1997. Thermally enhanced removal of liquid hydrocarbon contaminants from soils and groundwater. Chapter 16 in Subsurface Restoration, edited by C.H.Ward, J.A. Cherry, and M.R. Scalf. Ann Arbor Press, Inc., Chelsea, Michigan, pp. 251-270.

REVIEW OF OFF-SITE HEALTH RISK ASSESSMENTS
MISSION VALLEY TERMINAL

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INTRODUCTION

RBTCs (Risk-Based Target Concentrations) have been developed by Kinder Morgan Energy Partners (Discharger) specific to the release of gasoline from the Mission Valley Terminal based upon the results of risk assessment calculations. Subsurface impacts of the release extend southward from Mission Valley Terminal, across the public right-of-ways of Friars and San Diego Mission Roads, and onto City Of San Diego Property.

The results of the Discharger's risk assessment and supporting technical work are included in:

ENVIRON/LFR Levine Fricke. Health Risk Assessment, Off-Site Areas – Mission Valley Terminal, 9950 and 9966 San Diego Mission Road, San Diego, CA. August 4, 2003. (HRA 2003),

ENVIRON. Supplemental Risk Assessment, Off-Site Areas – Mission Valley Terminal, 9950 and 9966 San Diego Mission Road, San Diego, CA. January 30, 2004. (Supplement 2004)

Levine-Fricke, Inc. Final Summary Report, TSO R9-2002-0042. Mission Valley Terminal, 9950 and 9966 San Diego Mission Road, San Diego, CA. January 30, 2004. (Summary 2004).

The RBTCs are based on calculated estimates of exposure and related health risks associated with the potential accumulation of VOCs from gasoline (such as benzene and MTBE) within building or enclosed spaces. These calculations are typically done with the intent of estimating reasonable maximum or upper-bound estimates of chemical concentrations that may be allowed to remain in soil and/or groundwater and not pose a significant health risk. Given the uncertainties associated with the theoretical assumptions and varying exposure scenarios, and multiple uncertain parameters used in the derivation of RBTCs, a conservative approach is warranted.

Of primary concern to the City is the potential impact of the gasoline release on the redevelopment of the Qualcomm Stadium Area (c.f. CoSD Statement of Remedial Criteria, February 2004) and on water supply uses in Mission Valley (CoSD Draft Concept Plan April 2004). Also of concern is potential impacts to subsurface utilities within the Friars Road and Sand Diego Mission Road right-of-ways.

Review of the health risk assessment documents referenced herein indicates that the Discharger has not fully addressed the primary concerns of the City. While the overall approach and methodology is generally consistent with accepted practices, a number of concerns are detailed in this review.

These concerns include:

1. Risk-based soil vapor and groundwater criteria developed in Supplement 2004 clearly demonstrate that the RBTCs are exceeded in the area north and northeast of the existing Qualcomm Stadium impacted by the fuels release from Mission Valley Terminal.

2. Future use scenarios as described in the RBTCs limit future site uses to commercial use. As noted in the (CoSD Statement of Remedial Criteria, February 2004), residential uses are clearly being contemplated even with a sports stadium redevelopment plan. In general, residential use is considered an unrestricted use criterion.

3. The theoretical basis for developing RBTCs where free phase gasoline occurs is incorrect. RBTCs developed for the area where free phase gasoline occurs (here referred to as LNAPL, light non-aqueous phase liquid) should be independent of groundwater concentrations.

4. Soil parameters used in the fate and transport calculations that form the basis for the RBTCs are based on limited site soils data that are not conservative. Default values as recommended by USEPA (2000) are judged to be more appropriate for the screening-level calculations.

5. Potential impacts to utilities within the public right-of-ways that overlie LNAPL have not been addressed.

6. Downgradient groundwater impacts were evaluated using a screening-level approach that should be revised based on the details of a water supply system design now available (CoSD Concept Study, April 2004) that specify production well rates and locations. Prior work by the Discharger has included a groundwater flow and transport model. Inclusion of the production well field into the groundwater model is appropriate and would be technically more defensible than the approach presented by the Discharger January 2004.

7. Potential discharge of fuel-contaminated groundwater into the San Diego River has not been evaluated despite the presence of MTBE in groundwater monitoring wells on both sides of the River.

Detailed explanations follow.

Comparison of Proposed RBTCs with Site Data (Point 1)

RBTCs were developed in HRA 2003 and revised calculations presented in Supplemental 2004. Benzene is the primary gasoline component responsible for health risks associated with the accumulation of VOCs into buildings and structures located within the City of San Diego Property. Thus benzene is the focus of this analysis, keeping in mind that it is not the only component of gasoline viewed to be responsible for health risks.

RBTCs for both groundwater and soil vapor are clearly exceeded for benzene, as summarized in **Tables 1 and 2.** The RBTCs for benzene in groundwater assume that benzene dissolved in water partitions into a gaseous (vapor) phase, migrates vertically through soil, and accumulates in a building or an enclosed space. The calculation methodology follows USEPA (2000), and is explained in the HRA and in Supplemental 2004. In general, benzene RBTCs for groundwater will increase as the depth to groundwater increases due to the increased travel distance and attenuation that occurs as the vapor moves through the subsurface. Summary statistics of groundwater concentrations were conducted by the discharger (Table 11, Supplemental 2003) for area of the parking lot where LNAPL does and does not occur. The average, maximum, and the 95% upper confidence limit (UCL) of the mean were reported for both cases and shown in **Table 1.**

Table 1. RBTCs for Benzene in Groundwater, Commercial Site Use.
(Benzene concentrations previously presented by the discharger as noted below.)

Location	Depth to water, ft.	RBTC, ug/L	Mean, ug/L	95% UCL ug/L**	Maximum ug/L
Parking Lot Area- Street NAPLs	15	16	**13,294**	**19,295**	**48,000**
Parking Lot Area- Street Non-NAPL	15	16	**62.2**	**133**	**6,400**
Offsite Area- CoSD Calculations February 2004	20	39.8 * 11.9 (residential), (Calculations in attach't 1)	**62.2**	**133**	**6,400**
Stadium Area- Subgrade	7	7.8	Not calculated	Not calculated	0.15J
Stadium Area- Street	37	48	Not calculated	Not calculated	0.15J

Values from Tables 11 and 13 of Supplemental 2003, and Attachment C of CoSD, February 2004. A copy of Attachment C has been included in this document.

* The residential (unlimited) site use is also evaluated for this example.

** The Upper Confidence Limit (UCL) was used as a reasonable maximum concentration value in the Supplemental Health Risk Assessment (2003)

Values in **bold** indicate RBTCs are exceeded.

Calculations were also presented in the February 2004 Statement of Remedial Criteria following the methodology used by the County of San Diego Department of Environmental Health (DEH). The methodology differed somewhat from that used by the Discharger; however, the results were similar and RBTCs are exceeded. A residential (unlimited) site use scenario was used. The difference between residential and commercial exposures and thus calculated RBTCs is further explained in the next section.

Soil vapor data can also be used to derive RBTCs. The results shown in **Table 1** are based on a calculation of the soil vapor concentration that can form from benzene dissolved in water. More directly, the soil vapor concentration can be measured and similarly be used to calculate RBTCs. **Table 2** summarizes the RBTC results presented in Table 14 of Supplement 2004. Review of **Table 2** shows that the RBTCs are exceeded at SV-1. SV-1 was located in an area where LNAPL occurs.

Table 2. Calculated Soil Vapor RBTCs for Benzene, Assumes source is groundwater or LNAPL Results as previously presented by the Discharger

Point	Location	Depth	RBTC, ppb-vapor	Reported Conc. 9/9/02
SV-1	Near Surface soil	3	530	**4300**
	Near water table soil	12	940	**5700**
SV-2	Near Surface soil	4	470	310*
	Near water table soil	29.5	2800	8.1*

From Table 3.4 of the HRA 2003, Table 14 of Supplement 2004
* see text, results are inconsistent with a groundwater source

Similar to the groundwater RBTCs, the soil vapor calculations are being used to evaluate the health impact associated with gasoline either dissolved in groundwater or existing as a free phase (LNAPL) at the water table. Consistent with this condition, the soil vapor concentrations should be expected to decrease towards the surface as observed at SV-1. However, as noted by the *-flagged data for SV-2, the results are not consistent with a groundwater or LNAPL source. These results are discussed in the HRA 2003 (page 41).

Finally, as noted by both **Tables 1 and 2**, the RBTCs vary as a function of the depth of either the groundwater source or of the soil vapor sample. Presentation of the RBTCs would be much easier to understand and apply if they are presented in a table format as a function of depth since water levels vary across the site.

Future Use Scenarios (Point 2)

Calculation of RBTCs to assess potential impacts to occupants of buildings impacted by subsurface vapors is a two-step process. First an estimate of exposure concentration of vapors in the building is conducted. The exposure concentration is then evaluated in terms of the building occupancy and use. The Discharger assumes that future uses are restricted to commercial uses. This effectively limits the end use of the site and disallows residential use. The difference between the end use scenarios lies within the assumed exposure parameters. **Table 3** lists the key parameters.

Table 3. Comparison of Commercial Versus Unrestricted Site Use Exposure Parameters

Parameter	Commercial	Residential (Unrestricted)
Daily exposure	12 hr/day	24 hr/day
Yearly exposure	250 days/yr	350 days/yr
Exposure duration	25 years	30 years
Example RBTC	100 ug/L	29.8 ug/L

Since risk is directly (linearly) related to the exposure, increasing exposure time leads to increased health risk. The example RBTC for a chemical in groundwater demonstrates the effect of increasing the overall assumed exposure time from 3,125 days to 10,500 days. Health risk is assumed in all of the calculations used by the Discharger to be directly proportional to exposure time.

Thus to allow unrestricted site use to be considered, the RBTCs need to be decreased by a factor of 3.36. An example of this 'conversion' is shown in the last line of **Table 3.**

The Presence of Residual Gasoline Contamination (LNAPL) (Point 3)

RBTCs for areas where LNAPL occurs were incorrectly developed based upon dissolved gasoline constituent concentrations in groundwater. As noted in EPA, June 2000 "When a residual phase is present; however, the vapor concentration is independent of the soil concentration but proportional to the mole fraction of the individual component of the residual phase mixture." In this case, benzene is the primary risk-driver and the proportion (mole fraction) of benzene in the residual gasoline determines the vapor phase concentration of benzene that occurs in soil. EPA has developed a separate methodology for the case where LNAPL occurs (EPA, June 2000). This approach is consistent with the calculation methodology used by the County of San Diego DEH as presented in the Statement of Remedial Criteria (CoSD, February 2004) and attachment 2.

RBTCs developed in the area of LNAPL should be independent of groundwater concentrations and LNAPL thickness. Vapor phase transport remains dependent on the soil properties. Using benzene as an example, calculation of the vapor concentrations originating from free phase gasoline should be done by Raoult's Law following an estimate of the mole fraction of benzene in the residual gasoline. An example of risk calculations follows that uses the DEH methodology and default parameters.

Table 4. Example health risk calculations for LNAPL at a depth of 20 feet, unlimited site use, following the DEH methodology using default soil properties. (An excess cancer risk greater than 1.0E-6 [a one in one million risk] is considered significant. For comparison ,the 1.55 E-3 risk is equivalent to a one in 645 risk.)

Source, depth = 20 ft	Excess Cancer Risk	Notes
LNAPL, MF= 0.01	1.55 E-3 (fails)	lower end, fresh gas (calculations included in attachment 2)
LNAPL, MF= 0.03	4.66 E-3 (fails)	upper end, fresh gas (Result presented in Statement of Remedial Criteria)
Water, Benzene=13,294 ug/l	1.12 E-3 (fails) (3.76 E-3 for commercial)	UCL value presented in Supplement 2004.

As noted, the health risk assessment calculations presented by the Discharger incorrectly determine RBTCs in the area where LNAPL occurs. Instead, the calculations focus on residual dissolved phase gasoline components. Comparison of the calculations using the groundwater concentration presented in HRA 2003 does show that the approach does provide similar RBTCs. However, since the LNAPL is located between the groundwater and the surface receptors, the LNAPL should be used as the vapor source.

Since LNAPL is to be remediated to the extent practicable, and the Discharger is under Order to remediate all offsite LNAPL by 2007, the RBTCs for LNAPL may not be required. Thus if this condition is enforced, the issue of health risks associated with LNAPL becomes irrelevant.

Soil and Other Physical Properties (Point 4)

The RBTCs are fundamentally based on the movement of volatile organic vapors (VOCs) from the subsurface into a building. For a given chemical, the soil properties are the primary factor determining contaminant mobility. Here because the relative air permeability of the soil is low, diffusion processes dominate, so the movement of vapors is effectively controlled by the open pore space within the soil.

As noted in (HRA, page 54), there are four critical (sensitive) physical parameters in the soil vapor risk calculations. The first is related to the soil properties. The other three are physical parameters used to define the model. These include:

1. The effective vadose zone diffusion coefficient. (c.f. EPA, June 2003 Guidance Manual, page 15; 2004 SAM Manual Section 6). The afore-referenced vapor transport models calculate the effective diffusion coefficient as a function of the air-filled pore space (Θ_{air}) and total porosity (n). Θ_{air} is the portion of the soil open to vapor movement. Small changes in Θ_{air} lead to large changes in the rate of diffusion of a vapor through soil.
2. The ratio of building volume to building area. This is primarily a function of the interior ceiling height, here appropriately assumed to be 10 feet (3.05 meters).
3. The depth to subsurface sources. These are location-specific within the area of investigation. Here it is generally assumed that the source is either LNAPL or dissolved components of gasoline located at the water table.
4. The building outdoor air exchange rate. Here a value of 0.83 exchanges per hour is used, consistent with DEH methodology.

The easiest way to decrease the effective vadose zone diffusion coefficient is to decrease the effective porosity by filling the pores with water. As the relative moisture content increase, the rate of vapor movement decreases so a wet soil will limit vapor movement. (A limiting case would be a fully saturated soil where no vapor flow can occur.) As calculated by either the model used by the Discharger, or by the County of San Diego methodology used in COSD, the change in rate with increasing water content is non-linear and relatively dramatic.

RBTCs were developed for the off-site risk assessment on the basis of four soil samples. These are described as sand in the HRA calculations. The default soil property values for sand assume that the water in the soil has drained freely and that the soil is at its residual water saturation. The effective diffusivity of a soil, De, is calculated by

$$D_e = D_{air} (\Theta_{air})^{10/3} / n^2$$ (Diffusion through water assumed negligible)

Where, D_{air}, is the diffusion coefficient for benzene in air (0.088 cm2/sec)
Θ_{air}, is the air filled porosity
n, is the total soil porosity

A comparison between the sample results and the HRA calculation default values follow in **Table 5** using the four soil types included in Supplement 2004.

Table 5: Comparison of Soil Properties Used in HRA Calculations, RBTCs for benzene using a target ECR of 1.0 E-6 (one in one million).

Sample	Soil A	Soil B	Soil C	Soil D	Default
Bulk Density, g/cm3	1.38	1.51	1.72	1.38	1.66
Total Porosity, n	0.495	0.432	0.349	0.485	0.375
Water-filled Porosity	0.193	0.154	0.211	0.095	0.053
Residual Saturation	Use 0.053	Use 0.053	Use 0.053	Use 0.053	0.053
D_{eff}, benzene cm^2/sec	0.0067	0.0066	0.0010	0.0163	0.0144
Example RBTC, benzene in water at 20 ft bgs, ug/L	0.115	0.125	0.70	0.06	0.09
Change versus default	1.27x inc.	1.38x inc.	7.7x inc.	0.66x dec	---

Calculations conducted using the Johnson-Ettinger model (EPA (2000), Version 3.0 as cited in the references). The default case calculations are included in attachment 3.

Soils as listed in Table 7.2 of the August 2003 HRA, and Table 5 of Supplement 2004:

Soil A: Parking Lot, 0- 18 feet bgs
Soil B: Stadium Area, 0- 18 feet bgs
Soil C: Stadium Area, 18- 27 feet bgs
Soil D: Stadium Area, 27- 37 feet bgs

The default values (Table 3, EPA 2003) are used in the HRA to represent a reasonable maximum soil property to support the RBTC calculations. The EPA default values assume that the soil has drained of water and has a saturation equal to the residual water saturation. The site-specific soil properties support significantly reduced RBTCs, as indicated in the table by a comparison of RBTCs for a slab-on-grade building 20 feet above groundwater contaminated by benzene (from gasoline). The use of these values is questioned because the soils in the off-site area are located beneath a parking lot, have been so for over 30 years, and should be expected to be relatively dry. Estimated rainfall rates used in the groundwater model described in Appendix A (Figure A-7) of HRA 2003 were less than 1 inch/year, supporting the contention that relatively low soil saturations should be expected and used in the RBTCs.

The RBTCs proposed by the Discharger are highly dependent on the soil properties. The use of 'wet soils' such as soil C that differs from the default calculations by a factor of 7 is not conservative and based on sparse data. Default parameter would be more appropriate for the screening level calculations.

A number of additional building-specific parameters are used in the RBTCs presented by the Discharger. The effect of these parameters was tested and the results are shown in **Table 6.**

Table 6. Comparison of Default and HRA building parameters

Parameter	Value Used	Default	Notes
Building Sides	31.5 ft	10 m (32.8 ft)	Assume 31.5 ft should be 32.8
Room height	10 ft	(8 ft)	10 ft is reasonable for a commercial building
Slab Thickness	1 ft (30.48 cm)	4 inches (10 cm)	
Foundation Depth (along perimeter)	Not stated, assume 1.5 ft (45.7 cm)	6 inches (15 cm)	
Floor-wall seam Crack Width	0.025	0.10	

The default soil property case is used to test the effect of the **Table 6** parameters. When all of these parameters (except room height) are changed to the default values the RBTC decreases slightly from 0.09 to 0.08 ug/L and the effect of varying the parameters from default is relatively insignificant. (Refer to attachments 3 and 4 for copies of the spreadsheet calculation).

In summary the RBTCs are strongly affected by the assumed soil moisture content. The other parameters used in the analysis have much less impact and the difference between default and the values used in the HRA is not significant. On the other hand, the soil moisture content values are significant and default values should be used to support the calculation of RBTCs.

Utilities (Point 5)

Subsurface impacts of the release extend southward from Mission Valley Terminal, across the right-of-ways for Friars and San Diego Mission Roads, and onto City Of San Diego Property. While limited data are available, it is likely that extensive LNAPL impacts occur within the Friars Road and San Diego Mission Road right-of-ways. The Discharger has not addressed potential impacts to utilites within these right-of-ways. Potential impacts include:

1. Deterioration of seals and gaskets by gasoline vapors.
2. Worker safety concerns, especially within deep excavations and trenches.
3. Potential vapor accumulation in utility vaults.
4. Ongoing source for dissolved phase gasoline in groundwater.

Review of City files shows that a number of significant number and types of subsurface utilities are located within the right-of-ways.

Downgradient groundwater impacts (Point 6)

The City has long held that water resources are a developable resource. A more developed plan for developing the water resources accessible from City of San Diego Property has recently been developed. In brief, a well field capable of producing 2 million gallons of water per day is feasible. The wells would be completed within the alluvial sediments of the Mission Valley.

Review of the work done by the Discharger (Summary 2004) shows that the deepest portion of the alluvial sediments occurs along a NE-trending channel, from the San Diego River channel towards the west side Qualcomm Stadium (**Figure 1**). The occurrence of MTBE in groundwater is coincident with the channel, likely a result of preferential flow along the channel. Based upon this initial review, the optimum location for the wellfield would be within the channel given the potential to encounter the deepest portion of alluvium and hence the highest well production rates.

Supplement 2004 presented a mass flux calculation based upon homogenous aquifer conditions and generalized assumptions regarding flow to a wellfield. Prior work conducted by the Discharger included the conduct of a groundwater flow and transport model to evaluate the fate and transport of MTBE within the aquifer. The model explicitly accounted for the change in alluvium thickness as shown by the depth to Friars Formation shown in **Figure 1**. It is recommended that the model be run to evaluate the potential impact of the MTBE on influent concentration to a water supply well field located within the deepest portion of alluvium within the City of San Diego property.

Potential Discharge of Contaminated Groundwater to the San Diego River (Point 7)

MTBE has been detected in groundwater on both sides of the San Diego River. The hydraulic relationship between the groundwater system and the San Diego River has not been adequately evaluated to determine if there is discharge of contaminated water into the San Diego River. If discharge is occurring then there are potential ecological impacts that would need to be evaluated.

CONCLUDING REMARKS

Future redevelopment of City of San Diego Property north and northeast of Qualcomm Stadium is clearly impacted by the presence of LNAPL gasoline and dissolved phase components of gasoline in groundwater. Benzene is the primary risk-driver. MTBE in groundwater is of concern to future water supply development.

From a general perspective, the area where significant impacts are expected is similar in extent whether commercial or residential (unrestricted) end uses are considered. The biggest concern, and the most significant from a remediation standpoint, is the presence of LNAPL. In terms of RBTCs, the impact of LNAPL is significant because the RBTCs are independent of LNAPL thickness. LNAPL also serves as a source for ongoing dissolution of benzene and MTBE to groundwater and hence ongoing exceedences of RBTCs. Thus redevelopment is severely constrained until the LNAPL is removed.

Recommendations

1. RBTCs should be revised to include an unrestricted land use scenario using default soil parameters. RBTCs for the area where LNAPL occurs should recognize LNAPL and not be based on dissolved gasoline component concentrations. Either the DEH or the USEPA LNAPL risk calculation methodology is applicable. In general, RBTCs associated with site redevelopment will be exceeded (fail) wherever LNAPL is present on City Property.

2. A vapor survey should be conducted within enclosed spaces and service vaults of existing utilities within the public Friars Road and San Diego Mission Road right-of-ways. Additional field-based assessment is necessary to support a determination whether significant impacts to utilities occur.

3. The groundwater model should be re-run to include the potential impacts of the MTBE plume on a 2 million gallon per day well field located within the deepest portion of alluvium within the City of San Diego Property.

4. The field investigation should be expanded to assess the potential discharge of contaminated groundwater into the San Diego River.

REFERENCES

City of San Diego. Statement of Remedial Criteria, Mission Valley terminal. February 2004.

City of San Diego. Draft Concept study, Mission Valley Groundwater Desalting Project, CoSD Water Department Water Policy and Planning Division, March 2004.

County of San Diego Site Assessment Manual.. Vapor phase risk assessment Excel software (last revised 8/25/03) available at:
http://www.sdcounty.ca.gov/deh/lwq/sam/vapor_risk_assessment_2000.html
DEH risk assessment approach described in:
http://www.sdcounty.ca.gov/deh/lwq/sam/pdf_files/manual_2003/section_6.pdf

ENVIRON/LFR Levine Fricke. Health Risk Assessment, Off-Site Areas – Mission Valley Terminal, 9950 and 9966 San Diego Mission Road, San Diego, CA. August 4, 2003.

ENVIRON. Supplemental Risk Assessment, Off-Site Areas – Mission Valley Terminal, 9950 and 9966 San Diego Mission Road, San Diego, CA. January 30, 2004.

ENVIRON, Draft Work Plan – Vapor Intrusion Pathway Assessment, On-Site Areas – Mission Valley Terminal, 9950 and 9966 San Diego Mission Road, San Diego, CA. February 27, 2004.

Levine-Fricke, Inc. Final Summary Report, TSO R9-2002-0042. Mission Valley Terminal, 9950 and 9966 San Diego Mission Road, San Diego, CA. January 30, 2004.

US EPA. User's Guide for Evaluating Subsurface Vapor Intrusion Into Buildings. June 2003. http://www.epa.gov/superfund/programs/risk/airmodel/guide.pdf

US EPA. User's Guide for the NAPL-screen and NAPL-Adv Models for Evaluating Subsurface Vapor Intrusion Into Buildings. June 2000.

US EPA Website: Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings.
http://www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm
Used Herein: GW-ADV Excel Version 3.0, dated 02/03

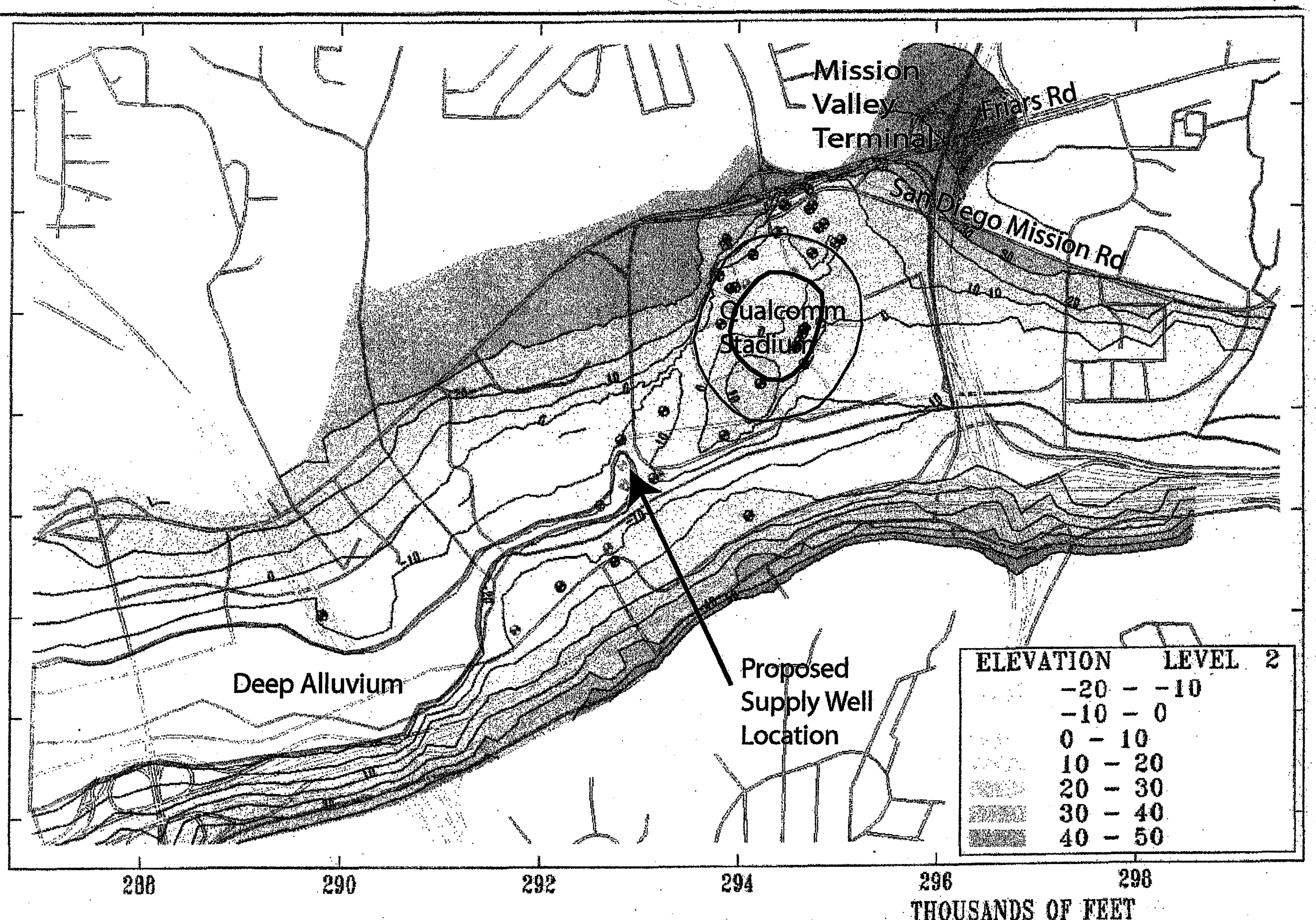
ATTACHMENTS

1. RBTC for Benzene in groundwater, depth = 20 ft. Follows DEH Methodology.

2. Calculation for Excess Cancer Risk, gasoline LNAPL, depth = 20 ft. Follows DEH Methodology.

3. USEPA Model GW-ADV, vapor transport calculations, default sand parameters, depth = 20 ft.

4. USEPA Model GW-ADV, vapor transport calculations, default sand parameter, KM building parameters, depth = 20 ft.



Elevation Contours of the top of Friars Foramtion
with boreholes that encountered that formation

Mission Valley Terminal

LFR LEVINE•FRICKE

FIGURE
A-5

Figure 1: Location of Proposed Groundwater Supply Wells

ATTACHMENT 1

RBTC for Benzene in groundwater, depth = 20 ft. Follows DEH Methodology.

Case Name:
Table 1, RBTC for Benzene in water, depth = 20 ft.

CHEMICAL OF CONCERN:

Enter Chemical Name = benzene

C11 benzene
C12 benzo(a)pyrene
C13 carbon tetrachloride
C14 chlorobenzene
C15 chloroethane (ethyl chloride)
C16 chloromethane (methyl chloride)
C17 1,2-dichlorobenzene
C18 1,3-dichlorobenzene
C19 1,4-dichlorobenzene
C20 1,1-dichloroethene (1,1-DCE)
C21 trans-1,2-dichloroethene
C22 1,1-dichloroethane (1,1-DCA)
C23 1,2-dichloroethane (1,2-DCA)

E11 dichloromethane (methylene chloride)
E12 ethylbenzene
E13 naphthalene
E14 methyl tertiary butyl ether (MTBE)
E15 tetrachloroethene (PCE)
E16 toluene
E17 1,1,1-trichloroethane
E18 1,1,2-trichloroethane
E19 trichloroethene (TCE)
E20 trichloromethane (chloroform)
E21 vinyl chloride
E22 xylene

Chemical Mixture (if app.) =

C27 Gasoline
C28 Kerosene
C29 Diesel

E27 Fuel Oil
E28 Waste Oil

If compound is not listed then data must be entered into the site-specific field.

SITE SPECIFIC INFORMATION			Site-Specific	Value Used
Mole fraction	dimensionless	MF		0.0000
Temperature	K	T		293
Water concentration (chemical)	ug/l	C_w	11.85	11.85
Soil concentration (chemical)	mg/kg	C_t		0
Soil concentration (TPH/TRPH)	mg/kg	C_t		0
Soil gas concentration (measured)	mg/m3 (ug/l)	$C_{sg}(m)$		0
Depth of contamination or Soil Gas	m	X	6.097560976	6.097560976

CHEMICAL PROPERTIES			Site Specific	Value Used
Henry's Law Constant	dimensionless	H		0.23
Vapor pressure	atm	VP		0.13
Molecular weight (chemical)	mg/mole	MW		78,110
Molecular weight (mixture)	mg/mole	MW(m)		#N/A
Universal gas constant	atm-m3/mole-K	R	XXXXXXXXXX	8.20E-05
Diffusion coefficient in air	cm2/sec	D_a		0.088
Organic carbon partitioning coef.	cm3/gm	K_{oc}		62

SOIL PROPERTIES				
Total porosity	dimensionless	θ		0.3
Air-filled porosity	dimensionless	θ_a		0.2
Water-filled porosity	dimensionless	θ_w	XXXXXXXXXXX	0.1
Bulk density (dry)	gm/cc	r_b		1.8
Weight fraction of organic carbon	dimensionless	foc		0.01
BUILDING SPECIFICATIONS				
Floor area of building	m2	A		1
% of floor area that flux occurs	dimensionless			100%
Interior Height of building	m	R_h		2.44
Exchange rate of air	exchanges/hr	E		0.83
Slab Attenuation factor	dimensionless	S_b		0.1
OUTDOOR AIR COMPONENT				
Downwind contamination length	m	L		0
Wind speed	m/hr	u		16000
Height of building openings	m	h		2
EXPOSURE SCENARIO Default values are for Industrial Uses				
Body weight	kg	BW		70
Inhalation rate	m3/day	IR		20
Exposure duration	yrs	ED	70	70
Hours per day	hr/day		24	24
Days per week	days/week		7	7
Weeks per year	weeks/yr			50
HEALTH RISK FACTORS				
Reference dose	mg/kg-day	RfD		0.0017
Slope factor (potency)	1/(mg/kg-day)	SF		0.1

SITE ASSESSMENT & MITIGATION VAPOR RISK ASSESSMENT MODEL
Risk Calculations

Case Name: #REF!

Chemical: benzene

Variable Descriptions				Units
CALCULATION OF SOIL GAS CONCENTRATION				
A. SOURCE - Free Product/Soil>100mg/kg.				
Mole fraction	MF	=	0.00E+00	dimensionless
Molecular weight	MW	=	7.81E+04	mg/mole
Vapor pressure	VP	=	1.30E-01	atm
Universal gas constant	R	=	8.20E-05	atm-m3/mole-K
Temperature	T	=	2.93E+02	K
Calculated soil gas concentration	C_{sg}(fp)	=	**0.00E+00**	mg/m3
B. SOURCE - Groundwater				
Water contamination level	C_w	=	1.19E+01	ug/l
Henry's Law Constant	H	=	2.30E-01	dimensionless
Calculated soil gas concentration	C_{sg}(gw)	=	**2.73E+00**	mg/m3
C. SOURCE - Soil < 100 mg/kg				
Soil contamination level	C_t	=	0.00E+00	mg/kg
Henry's Law Constant	H	=	2.30E-01	dimensionless
Bulk density (dry)	ρ_b	=	1.80E+00	gm/cc
Air-filled porosity	θ_a	=	2.00E-01	dimensionless
Water-filled porosity	θ_w	=	1.00E-01	dimensionless
Soil/water distribution coef.	K_d	=	6.20E-01	cm3/gm
Calculated soil gas concentration	C_{sg}(s)	=	**0.00E+00**	mg/m3
D. SOURCE - Measured Soil Gas				
Measured soil gas concentration	C_{sg}(m)	=	**0.00E+00**	mg/m3 (ug/l)

E. SOIL GAS CONCENTRATION USED IN RISK CALCULATIONS >>>> 2.73E+00 mg/m3

DIFFUSIVE TRANSPORT UPWARD IN UNSATURATED ZONE				
Total porosity	θ	=	3.00E-01	dimensionless
Air-filled porosity	θ_a	=	2.00E-01	dimensionless
Diffusion coefficient in air	D_a	=	8.80E-02	cm2/sec
Effective diffusion coefficient	D_e	=	**4.60E-03**	cm2/sec
Depth of contamination or Csg	X	=	6.10E+00	m
Calculated Flux	F_x	=	**7.40E-04**	mg/m2-hour

Case Name: **#REF!**

CALCULATING VAPOR CONCENTRATION IN BUILDING

A. INDOOR AIR COMPONENT

Floor area of building	A	=	1.00E+00	m2
% of floor area that flux occurs			1.00E+00	dimensionless
Slab Attenuation factor	S_b	=	1.00E-01	dimensionless
Flux area within building	Af	=	**1.00E-01**	m2
Interior Height of building	R_h	=	2.44E+00	m
Volume of building	V	=	**2.44E+00**	m3
Exchange rate of air	E	=	8.30E-01	exchanges/hr
Ventilation rate	Q	=	**2.03E+00**	m3/hr
Indoor air component	C_i	=	**3.65E-05**	**mg/m3**

B. OUTDOOR AIR COMPONENT

Downwind contamination length	L	=	0.00E+00	m
Wind speed	u	=	1.60E+04	m/hr
Height of building openings (or height of breathing zone)	h	=	2.00E+00	m
Outdoor air component	C_o	=	**0.00E+00**	**mg/m3**
C. TOTAL INDOOR AIR CONCENTRATION	C_t	=	**3.65E-05**	**mg/m3**

EXPOSURE SCENARIO

Body weight	BW	=	7.00E+01	kg
Inhalation rate	IR	=	2.00E+01	m3/day
Exposure duration	ED	=	7.00E+01	yrs
Hours per day	conversion		2.40E+01	hr/day
Exposure time	ET	=	**1.00E+00**	hr/24 hours
Days per week	conversion		7.00E+00	days/week
Weeks per year	conversion		5.00E+01	weeks/yr
Exposure frequency	EF	=	**3.50E+02**	days/yr
Averaging Time (carc. risk)	AT	=	2.56E+04	days
Averaging Time (non-carc. risk)	AT	=	**2.56E+04**	days
Chemical Intake (carc. risk)	IT_c	=	**1.00E-05**	**mg/kg-day**
Chemical Intake (non-carc. risk)	IT_{nc}	=	**1.00E-05**	**mg/kg-day**

NON-CARCINOGENIC RISK (Chronic Risk)

Chemical Intake (non-carc. risk)	IT_{nc}	=	1.00E-05	mg/kg-day
Reference dose	RfD	=	1.70E-03	mg/kg-day
Hazard Index	**HI**	=	**5.89E-03**	

CARCINOGENIC RISK

Chemical Intake (carc. risk)	IT_c	=	1.00E-05	mg/kg-day
Slope factor (potency)	SF	=	1.00E-01	1/(mg/kg-day)
Cancer Risk	**Risk**	=	**1.00E-06**	

ATTACHMENT 2

**Calculation for Excess Cancer Risk (ECR) , gasoline LNAPL, depth = 20 ft.
Follows DEH Methodology.**

Case Name: [redacted]

Table 4, ECR for Benzene in LNAPL, depth = 20 ft.

CHEMICAL OF CONCERN:

Enter Chemical Name = benzene

C11 benzene
C12 benzo(a)pyrene
C13 carbon tetrachloride
C14 chlorobenzene
C15 chloroethane (ethyl chloride)
C16 chloromethane (methyl chloride)
C17 1,2-dichlorobenzene
C18 1,3-dichlorobenzene
C19 1,4-dichlorobenzene
C20 1,1-dichloroethene (1,1-DCE)
C21 trans-1,2-dichloroethene
C22 1,1-dichloroethane (1,1-DCA)
C23 1,2-dichloroethane (1,2-DCA)

E11 dichloromethane (methylene chloride)
E12 ethylbenzene
E13 naphthalene
E14 methyl tertiary butyl ether (MTBE)
E15 tetrachloroethene (PCE)
E16 toluene
E17 1,1,1-trichloroethane
E18 1,1,2-trichloroethane
E19 trichloroethene (TCE)
E20 trichloromethane (chloroform)
E21 vinyl chloride
E22 xylene

Chemical Mixture (if app.) = Gasoline

C27 Gasoline
C28 Kerosene
C29 Diesel

E27 Fuel Oil
E28 Waste Oil

If compound is not listed then data must be entered into the site-specific field.

SITE SPECIFIC INFORMATION			Site-Specific	Value Used
Mole fraction	dimensionless	MF	0.0100	0.0100
Temperature	K	T		293
Water concentration (chemical)	ug/l	C_w		0
Soil concentration (chemical)	mg/kg	C_t		0
Soil concentration (TPH/TRPH)	mg/kg	C_t		0
Soil gas concentration (measured)	mg/m3 (ug/l)	$C_{sg}(m)$		0
Depth of contamination or Soil Gas	m	X	6.097560976	6.097560976

CHEMICAL PROPERTIES			Site Specific	Value Used
Henry's Law Constant	dimensionless	H		0.23
Vapor pressure	atm	VP		0.13
Molecular weight (chemical)	mg/mole	MW		78,110
Molecular weight (mixture)	mg/mole	MW(m)		100,000
Universal gas constant	atm-m3/mole-K	R	XXXXXXXXXX	8.20E-05
Diffusion coefficient in air	cm2/sec	D_a		0.088
Organic carbon partitioning coef.	cm3/gm	K_{oc}		62

SOIL PROPERTIES				
Total porosity	dimensionless	θ		0.3
Air-filled porosity	dimensionless	θ_a		0.2
Water-filled porosity	dimensionless	θ_w	XXXXXXXXXX	0.1
Bulk density (dry)	gm/cc	r_b		1.8
Weight fraction of organic carbon	dimensionless	foc		0.01
BUILDING SPECIFICATIONS				
Floor area of building	m2	A		1
% of floor area that flux occurs	dimensionless			100%
Interior Height of building	m	R_h		2.44
Exchange rate of air	exchanges/hr	E		0.83
Slab Attenuation factor	dimensionless	S_b		0.1
OUTDOOR AIR COMPONENT				
Downwind contamination length	m	L		0
Wind speed	m/hr	u		16000
Height of building openings	m	h		2
EXPOSURE SCENARIO Default values are for Industrial Uses				
Body weight	kg	BW		70
Inhalation rate	m3/day	IR		20
Exposure duration	yrs	ED	70	70
Hours per day	hr/day		24	24
Days per week	days/week		7	7
Weeks per year	weeks/yr			50
HEALTH RISK FACTORS				
Reference dose	mg/kg-day	RfD		0.0017
Slope factor (potency)	1/(mg/kg-day)	SF		0.1

SITE ASSESSMENT & MITIGATION VAPOR RISK ASSESSMENT MODEL
Risk Calculations

Case Name: 0

Chemical: benzene

Variable Descriptions				**Units**
CALCULATION OF SOIL GAS CONCENTRATION				
A. SOURCE - Free Product/Soil>100mg/kg.				
Mole fraction	MF	=	1.00E-02	dimensionless
Molecular weight	MW	=	7.81E+04	mg/mole
Vapor pressure	VP	=	1.30E-01	atm
Universal gas constant	R	=	8.20E-05	atm-m3/mole-K
Temperature	T	=	2.93E+02	K
Calculated soil gas concentration	C_{sg}(fp)	=	**4.23E+03**	**mg/m3**
B. SOURCE - Groundwater				
Water contamination level	C_w	=	0.00E+00	ug/l
Henry's Law Constant	H	=	2.30E-01	dimensionless
Calculated soil gas concentration	C_{sg}(gw)	=	**0.00E+00**	**mg/m3**
C. SOURCE - Soil < 100 mg/kg				
Soil contamination level	C_t	=	0.00E+00	mg/kg
Henry's Law Constant	H	=	2.30E-01	dimensionless
Bulk density (dry)	ρ_b	=	1.80E+00	gm/cc
Air-filled porosity	θ_a	=	2.00E-01	dimensionless
Water-filled porosity	θ_w	=	1.00E-01	dimensionless
Soil/water distribution coef.	K_d	=	6.20E-01	cm3/gm
Calculated soil gas concentration	C_{sg}(s)	=	**0.00E+00**	**mg/m3**
D. SOURCE - Measured Soil Gas				
Measured soil gas concentration	C_{sg}(m)	=	**0.00E+00**	**mg/m3 (ug/l)**

E. SOIL GAS CONCENTRATION USED IN RISK CALCULATIONS >>>> **4.23E+03 mg/m3**

DIFFUSIVE TRANSPORT UPWARD IN UNSATURATED ZONE				
Total porosity	θ	=	3.00E-01	dimensionless
Air-filled porosity	θ_a	=	2.00E-01	dimensionless
Diffusion coefficient in air	D_a	=	8.80E-02	cm2/sec
Effective diffusion coefficient	D_e	=	**4.60E-03**	cm2/sec
Depth of contamination or Csg	X	=	6.10E+00	m
Calculated Flux	F_x	=	**1.15E+00**	**mg/m2-hour**

Case Name: 0

CALCULATING VAPOR CONCENTRATION IN BUILDING

A. INDOOR AIR COMPONENT

Floor area of building	A	=	1.00E+00	m2
% of floor area that flux occurs			1.00E+00	dimensionless
Slab Attenuation factor	S_b	=	1.00E-01	dimensionless
Flux area within building	Af	=	**1.00E-01**	m2
Interior Height of building	R_h	=	2.44E+00	m
Volume of building	V	=	**2.44E+00**	m3
Exchange rate of air	E	=	8.30E-01	exchanges/hr
Ventilation rate	Q	=	**2.03E+00**	m3/hr
Indoor air component	C_i	=	**5.67E-02**	**mg/m3**

B. OUTDOOR AIR COMPONENT

Downwind contamination length	L	=	0.00E+00	m
Wind speed	u	=	1.60E+04	m/hr
Height of building openings (or height of breathing zone)	h	=	2.00E+00	m
Outdoor air component	C_o	=	**0.00E+00**	**mg/m3**

C. TOTAL INDOOR AIR CONCENTRATION

C. TOTAL INDOOR AIR CONCENTRATION	C_t	=	**5.67E-02**	**mg/m3**

EXPOSURE SCENARIO

Body weight	BW	=	7.00E+01	kg
Inhalation rate	IR	=	2.00E+01	m3/day
Exposure duration	ED	=	7.00E+01	yrs
Hours per day	conversion		2.40E+01	hr/day
Exposure time	ET	=	**1.00E+00**	hr/24 hours
Days per week	conversion		7.00E+00	days/week
Weeks per year	conversion		5.00E+01	weeks/yr
Exposure frequency	EF	=	**3.50E+02**	days/yr
Averaging Time (carc. risk)	AT	=	2.56E+04	days
Averaging Time (non-carc. risk)	AT	=	**2.56E+04**	days
Chemical Intake (carc. risk)	IT_c	=	**1.55E-02**	**mg/kg-day**
Chemical Intake (non-carc. risk)	IT_{nc}	=	**1.55E-02**	**mg/kg-day**

NON-CARCINOGENIC RISK (Chronic Risk)

Chemical Intake (non-carc. risk)	IT_{nc}	=	1.55E-02	mg/kg-day
Reference dose	RfD	=	1.70E-03	mg/kg-day
Hazard Index	**HI**	=	**9.13E+00**	

CARCINOGENIC RISK

Chemical Intake (carc. risk)	IT_c	=	1.55E-02	mg/kg-day
Slope factor (potency)	SF	=	1.00E-01	1/(mg/kg-day)
Cancer Risk	**Risk**	=	**1.55E-03**	

ATTACHMENT 3

USEPA Model GW-ADV, vapor transport calculations, default sand parameter, depth = 20 ft.

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
71432	9.00E-02	Benzene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm) — Totals must add up to value of L_{WT} (cell G28)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
21.1	15	609.7560976	609.7560976	0	0	A	S			1.00E-07

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
S	1.66	0.375	0.054	S	1.66	0.375	0.054	S	1.66	0.375	0.054

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	10	1000	1000	3.04878048E	0.1	0.83	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3$)$^{-1}$	Reference conc., RfC (mg/m^3)
8.80E-02	9.80E-06	5.54E-03	25	7,342	353.24	562.16	5.89E+01	1.79E+03	7.8E-06	0.0E+00

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
9.46E+08	594.7560976	0.321	0.321	0.321	#N/A	#N/A	#N/A	1.00E-07	17.05	0.375	0.122	0.253	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
7.03E+02	1.06E+06	3.77E-04	15	8,008	4.63E-03	1.92E-01	1.79E-04	1.42E-02	0.00E+00	0.00E+00	5.67E-04	8.42E-03	594.7561

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF ($\mu g/m^3$)$^{-1}$	Reference conc., RfC (mg/m^3)
15	1.73E+01	0.10	8.33E+01	1.42E-02	4.00E+02	3.99E+63	1.81E-02	3.12E-01	7.8E-06	NA

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	1.79E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.0E-06	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

ATTACHMENT 4

USEPA Model GW-ADV, vapor transport calculations, default sand parameter, KM building parameters, depth = 20 ft.

DATA ENTRY SHEET

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
71432	8.00E-02	Benzene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
21.1	45.73170732	609.7560976	609.7560976	0	0	A	S			1.00E-07

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
S	1.66	0.375	0.054	S	1.66	0.375	0.054	S	1.66	0.375	0.054

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
30.48780488	4	960.3658537	960.3658537	3.048780488	0.025	0.83	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based groundwater concentration.

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
9.46E+08	564.0243902	0.321	0.321	0.321	#N/A	#N/A	#N/A	1.00E-07	17.05	0.375	0.122	0.253	3,841

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
6.48E+02	1.10E+06	8.75E-05	45.7317073	8,008	4.63E-03	1.92E-01	1.79E-04	1.42E-02	0.00E+00	0.00E+00	5.67E-04	8.23E-03	564.02439

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
45.73170732	1.53E+01	0.03	8.33E+01	1.42E-02	9.60E+01	#NUM!	2.07E-02	3.18E-01	7.8E-06	NA

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	1.79E+06	NA

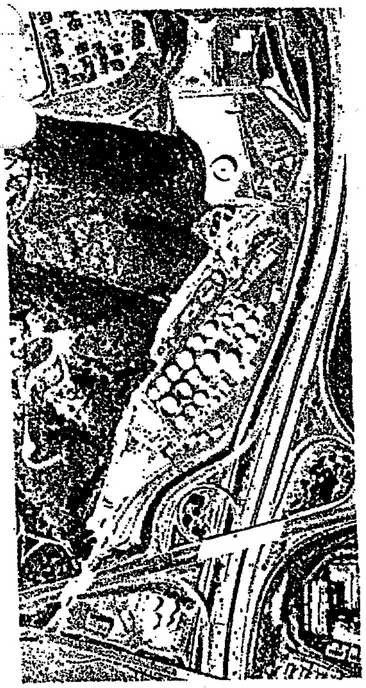
INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.0E-06	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END



Prepared for:

Regional Water Quality Control Board, Region 9

Clean-Up and Abatement Order (CAO) No. 92-01

Time Schedule Order No. R9-2002-0042

CITY OF SAN DIEGO'S

STATEMENT OF REMEDIAL CRITERIA MISSION VALLEY TERMINAL

February 2004

Letter Report:	City of San Diego's Statement of Remedial Criteria Mission Valley Terminal Clean-Up and Abatement Order (CAO) No. 92-01 Time Schedule Order No. R9-2002-0042
Prepared for:	Regional Water Quality Control Board, Region 9
Prepared on behalf of:	The City of San Diego
By:	Mission Valley Terminal Working Group For the City of San Diego
Dated:	February 2, 2004

Table of Contents:

Introduction:

The purpose of this document is to provide the Regional Water Quality Control Board (RWQCB) for the San Diego Region with information about the City of San Diego's position on the regulatory and legal criteria for addressing the contamination from the Mission Valley Terminal (MVT). Petroleum products have been discharged to the ground and groundwater from the Mission Valley Terminal (sometimes referred to as the Site) since 1986. (See, Attachment A, "Regulatory History".) The RWQCB first issued a Clean Up and Abatement Order in 1992 (CAO 92-01) for this Site. In the last few years the City of San Diego has been included as a recipient of various submittals that Kinder Morgan Energy Partners, L.P., the Discharger at the Site, has been ordered to make to the RWQCB concerning their remedial investigations. The Discharger has been ordered to propose an overall plan for remedial activity on February 2, 2004, pursuant to Time Schedule Order No. R9-2002-0042, adopted by the RWQCB on March 13, 2002. In response, the City of San Diego created a Working Group, representing a variety of disciplines, to evaluate proposals and provide relevant and timely information concerning the criteria that the RWQCB should consider as it evaluates the Discharger's response to its Order. Through submittal of this document, the Working Group intends to provide significant factual, policy, and legal criteria to the RWQCB as it considers the Discharger's plans for remediation of the Site.

The City is a critical stakeholder in this matter for several reasons. First, the City is the appropriate and relevant governmental authority with jurisdiction to plan and approve use of the natural resources impacted by this release. The City not only has local land use authority and jurisdiction for the property immediately down gradient from the area of the release, it actually owns it. This property is currently used for the Qualcomm Stadium and adjacent parking, but the City has concluded that land use changes in this area are reasonably foreseeable. In addition, the City has pueblo rights to the water of the San Diego River, and has historically had production wells in the area threatened by the release at this Site. The City is now planning for groundwater storage and extraction as part of a groundwater management program, and its plans for this aquifer will be directly impacted by RWQCB decisions for remediation at this Site.

This Letter Report and its attachments are submitted by the Working Group, but that group has not yet had sufficient time to fully assess all available information. In particular, neither the Working Group nor the RWQCB has yet seen the Discharger's plans for meeting reasonable remedial deadlines for mitigation of the releases. Technical consultants to the group are also working on an independent evaluation of reasonable and feasible remedial alternatives to address the City's requirements for the aquifer and the future land-use at this site, and this supplemental information will be submitted to the RWQCB by the Working Group as soon as it is available. The Working Group will remain available to provide additional supplemental information and coordination that may be useful to the RWQCB throughout its deliberations on these issues.

Respectfully submitted,

Richard G. Mendes, City of San Diego,
Deputy City Manager/Utilities General Manager

Larry Gardner, City of San Diego,
Water Department Director

Chris Gonaver, City of San Diego,
Environmental Services Department Deputy Director

/s/ Richard Jackson (see attached page)

Dr. Richard E. Jackson, P. Eng.,
Intera, Inc.,
Consultant for the City

/s/ Jay Jones (see attached page)

Dr. Jay Jones, R.G. 4106,
Environmental Navigation Services, Inc.
Consultant for the City

Grace C. Lowenberg, Esq.,
Deputy City Attorney
San Diego City Attorney's Office

Richard G. Opper, Esq.,
Opper & Varco LLP,
Special Counsel to City Attorney

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Special Counsel to City Attorney

Executive Summary:

The Working Group is concerned that the Discharger's remedial approach to this site has been one of insufficient attention, despite RWQCB Orders and CAO 92-01. Until recently, the Discharger made very little effort to define the limits and assess the causes of the unauthorized release that occurred at the Mission Valley Terminal. At the conclusion of a recent arbitration finding that Kinder Morgan Energy Partners L.P., successor to Santa Fe Pipeline Partners, was solely responsible for the core plume, the arbitrator, Judge Altman of the Superior Court (Ret.) wrote that the SFPP/Kinder Morgan remediation efforts from 1994 until at least 1998 were an "unmitigated disaster". As a result of too many years of the Discharger's indifference, remedial strategies for the mitigation of this release now require more aggressive efforts to avoid even greater damage to the natural resources and to achieve clean-up on a schedule that will meet the City's needs. The Discharger should not now complain of the level of effort required to address their releases, because the current situation is the result of nothing more than their own past perfunctory approach.

A review of various reports submitted to the RWQCB suggests that the Discharger's analysis of both the spatial distribution and total volume of the released gasoline and the performance of the remediation system installed to remove the gasoline is incomplete or, simply, absent. A relatively recent submittal (Levine Fricke Mass Flux Report, p. 1, dated June 6, 2003) noted that the Soil Vapor Extraction recovery system at the facility was reaching near-zero returns in several wells, and noted that "Near zero recovery rates by recovery systems typically reflect depletion of LNAPL saturation…" However, some of these wells that are producing "near zero" recovery are located in areas that as recently as August 2003 had in excess of 1,000 µg/L of dissolved benzene in the sampled ground water and that historically have recorded free-phase gasoline. Rather than reflecting the depletion of LNAPL, the Working Group is most concerned that the near-zero recovery may be demonstrating the ineffectiveness of the recovery system.

The Working Group wishes to make it very clear that the City's goal is to achieve conditions of decontamination of the subsurface beneath the Qualcomm Stadium parking lot so that the process for development of the aquifer can begin in 2005, not the long-term capture and incomplete removal of gasoline that is the unstated objective that emerges from the July 2003 Technical Evaluation Report (TER) on the MVT remediation system. Consequently, references in the TER suggesting the impracticability of further gasoline removal once vapor recovery reaches asymptotic levels are simply unacceptable to the Working Group and should be unacceptable to the RWQCB.

The Working Group, aided by its technical consultants, has concluded that there is inadequate data available to assess just how much LNAPL is now presently trapped beneath the Stadium parking lot. Therefore, there is no logical way to determine the success rate (or failure) of a recovery system, and no way to establish the time necessary for its successful implementation. The Working Group therefore recommends that additional assessment be immediately required in order that these significant questions can be answered, and before any particular remedial goals proposed by the Discharger be adopted. This additional assessment should address not only the LNAPL Source Zone Characterization Report described on page 12 of this letter report, but also a performance assessment (PA) of the present remediation system by a third-party expert knowledgeable in the recovery of gasoline from soil and ground water. The City would welcome this being conducted by Professor Paul Johnson, but appreciates his limited availability and wishes to stress the need for rapid assessment of performance. The terms of reference of this PA would be to evaluate the efficacy of the present system to recover gasoline, dissolved gasoline components and gasoline vapors from beneath the Qualcomm Stadium Parking Lot in the course of the next seventeen months. Both studies need to be completed in the next several months to assure sufficient time to implement its findings without further threatening the valuable groundwater resource in this region.

The City urges the RWQCB to order, on an expedited basis, further analysis of the total volume and spatial distribution of the trapped LNAPL beneath the Stadium parking lot, and a contemporaneous study of the physical characteristics of the aquifer the release has contaminated, in order that further damage to the resource can be minimized. The remedial strategy employed by the Discharger must accommodate the development of this aquifer, a process that was planned to begin next year, in 2005.

Legal, Regulatory and Policy Issues

Resolution of certain issues regarding the ultimate clean-up of this Site will be guided by regulations and policies of the RWQCB. Accordingly, the Working Group will offer its views about relevant policies and what they imply for the cleanup levels and the time-schedule for the cleanup of this Site. In addition, as with many sites of this magnitude, and particularly those in which public agencies and municipalities are significant stakeholders, there are significant, related determinations for which agencies other than the RWQCB have primary jurisdiction. For example, the RWQCB should defer to the findings and determinations of the City about local land use matters because land use issues are particularly within the jurisdiction of municipal government. Hence, RWQCB approval of plans submitted by the Discharger should be informed and guided by the City's goals and plans, particularly for those determinations within the City's jurisdiction, as identified in this submittal and in future submittals.

RWQCB policies require that cleanup and mitigation of these releases be sufficient, in timeliness and effectiveness, to support future uses that may provide for higher and better use of the Site. In the Basin Plan adopted by this Regional Board for the San Diego area (Sept. 8, 1994), "Cleanup And Abatement Principles" are stated on page 4-90. Among those principles recited in the Basin Plan is the following: "Dischargers are required to abate the effects of discharges in a manner that promotes…the best water quality…considering all the demands being made *and to be made* on those waters…." [Emphasis added.] This language mirrors that found in Resolution 92-49 of the State Water Resources Control Board, Section III (Implementation Procedures), section G. Resolution 92-49 additionally requires that mitigation efforts by a discharger be "consistent with maximum benefit to the people of the state" (see, section II. G. 1) and not unreasonably affect "present *and anticipated* beneficial use…of such water (see, Section III G. 2, emphasis added). The future likelihood of changing uses, for both the aquifer and the land above it, must therefore be taken into account by the Discharger when proposing mitigation plans. No less is required if the RWQCB is to remain true to SWRCB Policy 68-16, the "anti-degradation" policy, which calls for maintaining the water quality level for the maximum benefit of the people of the state whenever it can be done.

The City respectfully submits that the RWQCB should defer to the City regarding the likelihood of redevelopment of the site and its changing land use, as well as questions or determinations of the timing for implementing a conjunctive (or "shared") groundwater use and storage program for the Mission Valley aquifer. With regard to land use, the City is the local land use authority for this area. Factual information provided in a later section of this Remedial Criteria Report will portray the level of interest and effort that is currently going into evaluations of the potential redevelopment of this land. California law provides that when assessing the extent (and value) of a property owner's rights in real estate, "reasonably foreseeable" changes to allowable uses must be considered, not merely the existing uses. This is because an attribute of property ownership is the ability to use land at its "highest and best use" – long recognized as a fundamental aspect of land rights. (See, *Sacramento S.R.R. vs. Heilbron*, (1909) 156 C 408.) The California Code of Civil Procedure makes it explicit that one of the "bundle of rights" owned by property owners includes the rights to "all the uses and purposes for which the property is reasonably adaptable and available." (See, CCP section 1263.320(a).) The applicable tests are 1) whether the property's physical characteristics will support the new use (*Hayward Union High School vs. Lemos* (1960) 187 CA2d 348) and 2) whether trends in development of property in the general vicinity (e.g. proximity to shopping centers, highways and available transportation facilities) will allow the higher use (*People ex rel Dep't of Public Works vs. City of Los Angeles*, (1963) 220 CA2d 345, 352.) Therefore, the City urges the RWQCB to use these criteria, adopt the "reasonably foreseeable" standard, and assess remedial approaches and milestones on that basis, deferring to the City's determination that future development of this Site meets these tests. Resolution of this issue should not be based on whether any particular redevelopment project has already been entitled or approved.

Similarly, the City respectfully submits that the RWQCB should inquire into, and defer to, the City's decisions about the aquifer at this site. There is little doubt of the strength of the City's interests and its long standing water rights. These water rights were adjudicated by California's Supreme Court over 70 years ago in *City of San Diego vs. Cuyamaca Water Co.*, reported at 209 Cal. 105 (1930). The City's rights are referred to as "pueblo water rights" because they flow from the earliest history of the City's use of the water, from its early pueblo beginnings at Mission San Diego, to the civil authority that followed Mexican independence in 1834, to the 1874 determination of California's Board of Land Commissioners (following statehood in 1850) that the City of San Diego had succeeded to all the water rights of the Pueblo of San Diego. Pueblo rights are the highest priority of water rights, and extend to the waters of the San Diego River and all native flows in the watershed, including groundwater supplies that contribute to the river.

Hence, the City has the right to fully use these waters, and its plans for the use of the groundwater aquifer should be given paramount consideration when evaluating cleanup proposals for this Site.

The RWQCB should not allow the Discharger to propose remedial alternatives and strategies for this site that ignore the future use of the historic production well field merely because the City Council has not yet endorsed a specific plan for conjunctive groundwater use. Ample evidence exists of the City's efforts to study, and its intent to use, the groundwater aquifer, and the City will ultimately make the final determination about timing and scope for such groundwater projects. The remedial requirements approved by the RWQCB for this site should ensure that this valuable resource, and the City's timing for its use, are not further compromised by the Discharger. It is the City's goal that its efforts and those of the RWQCB be harmonized so that the natural resources at stake, both the groundwater aquifer and the land above it, can be protected to the maximum amount for the people of this community.

Aquifer and Natural Resource Concerns of City

The City and other public agencies have been studying the Mission Valley aquifer for some time. Historic production records for this aquifer establish that it was used for production wells by the City during the 1930s through the 1940's, and likely as early as 1914. The City of San Diego is currently evaluating groundwater management options for the aquifer systems that occur within the San Diego River. A recent study entitled "San Diego River System Conceptual Groundwater Management Plan", dated May 2003, provides a detailed assessment of the known and potential water uses for the aquifer system currently impacted by the discharge of fuel contaminants from Mission Valley Terminal. The aquifer system will provide groundwater that is derived from water naturally replenished by rainfall recharge. The aquifer system is also being recharged by reclaimed water in the area of Santee Lakes by the Padre Dam Water District. In the future, groundwater use can also be offset by the artificial recharge of imported water and expansion of reclaimed water recharge. These activities when coupled to groundwater use are described as conjunctive uses.

As reported in the May 2003 Management Plan, the operational storage capacity of the portion of the San Diego River System impacted by the MVT release is 11,000 acre-feet. The current safe yield, here defined as the volume of water that can be withdrawn on an annual basis and be replenished by recharge, is estimated to be 2,100 acre-feet. The recharge of imported water to the aquifer, may allow a long-term sustainable use considerably greater than this value. For example, if conjunctive uses are implemented to offset groundwater withdrawals, an additional storage capacity of 8900 acre-feet becomes available for groundwater storage and withdrawals. However, such beneficial use of the aquifer is dependent on resolving a number of technical issues, the first of which noted in section 6.3.2.3 of the Management Plan is the impact of the MVT upon groundwater quality.

Conjunctive groundwater uses offer a number of economic and operational opportunities to the City of San Diego:

1. Operational storage capacity of an estimated 11,000 acre-feet of water out of a total storage estimated to be 30,000 acre-feet.
2. Seasonal purchase of imported water to take advantage of lower water rates when available.
3. Controlled artificial recharge of reclaimed and poor quality import water or storm water provides for secondary water treatment.
4. Emergency storage
5. Routine storage in concert with adjacent surface water reservoirs within the San Diego River System (for example El Capitan Reservoir, San Vicente Reservoir, and Lake Jennings).

This study was commissioned as a result of grants provided by the State Department of Water Resources pursuant to AB 303. This law, the Local Groundwater Management Assistance Act of 2000, provides for assistance to agencies to conduct groundwater studies or to carry out groundwater monitoring and management activities, and reflects the State's recognition of the importance of the sound management of local water supplies.

The groundwater basin has also been studied by the San Diego County Water Authority, and addressed in a "Groundwater Report" dated June 1997. That report assessed withdrawal of approximately 2,000 AF/Y of groundwater from the Mission Valley alluvial aquifer to provide a potential yield of 1,600 AF/Y of potable water. The study concludes that additional studies are required for the development of these groundwater supplies, and determines that "these studies are warranted". (SDCWA Groundwater Report, June 1997, Section 6.2.2, page 6-12.)

The City also has a joint funding agreement with the US Geological Survey to perform well water quality sampling and analysis, including the Mission Valley aquifer, in early 2004. This agreement includes drilling a test well within the next six months. These data (and others that the Discharger should provide pursuant to RWQCB Orders) should provide the basis for moving forward with the next development steps in order that production and storage projects are operational by 2010. The City's best current estimates require the inception of work to this end must occur by 2005, and contamination must be resolved on a consistent timetable.

The City has not yet hired economists to value these uses of the aquifer, but initial order-of-magnitude studies suggest that the value is measured in the tens of millions of dollars over time, and the potential for inadequate or untimely remediation efforts to impact these uses creates significant damages that would be borne by the public, on whose behalf these actions are taken. Therefore, it is vital to the City's future needs that the Discharger immediately undertake a full and complete characterization of the LNAPL source zone beneath the Stadium parking lot, which is responsible for the continuing vapor- and dissolved-phase contamination in the subsurface at the Site. This and related characterization projects are considered in detail in the section below entitled Additional Assessment Requirements. The Working Group respectfully requests the RWQCB to order the Discharger to develop this data immediately in order to realistically assess remedial strategies and opportunities.

Future Land-Use Concerns of City

In a January 8, 2004, letter from the Executive Director of the RWQCB to the Discharger, it was related that potential redevelopment of the site is "speculative" at this time. As a result, the Discharger was advised to propose clean-up levels and milestone clean-up dates based on the current land use, which is, for the most part, a 30 acre stadium in the midst of over 130 acres of parking lot. The City respectfully proposes that the RWQCB defer to the City on the issue of potential future redevelopment of this site, in light of the City's local land use authority and obligations. As such, the question ought not be whether any particular project has been approved or entitled, but whether it is reasonably foreseeable that such future changes in land use will occur. The Working Group urges the RWQCB to accept that such future changes in land use are virtually inevitable, given the demographics of our community, our housing shortage, and the limited amount of urban in-fill land available for such redevelopment.

The potential redevelopment of this site has actually been the subject of considerable reporting in the San Diego Union-Tribune. Over 400 articles and many editorials have been written on the likelihood or possibility of impending change. A very public process of consideration for a potential change in use has been ongoing for more than a year, and although no particular proposal has yet been formally presented to the Redevelopment Agency for the City of San Diego (pursuant to its authority under Health and Safety Code section 33003 et seq.) to consider the adoption of a Project Area, redevelopment could occur even if no Project Area has been designated, as the land is already in the ownership and control of the City.

Further, considerable money and effort has already gone into preliminary studies for the intensification of the urban uses of this land. These studies have a common theme – more residential housing. As an example of the approach that a developer of this land could take (although not formally submitted for consideration at this time) the San Diego Chargers undertook a study (dated August 2003) that considered a variety of approaches that could be used. The portion of their study that is entitled "Site Concepts" is copied and included as Attachment B to this report. Significantly, all of the proposed development concepts include approximately 6,000 new additional residential units.

It therefore seems inappropriate to consider a clean-up plan, or remedial milestones, that do not take this reasonably foreseeable future residential use into account. If the cleanup plan is designed and approved assuming that the site is permanently configured as a surface parking lot, it will limit public choices and constrain public use of the land when future redevelopment evolves from its current conceptual stage to more formal proposals. It is simply impossible to plan a mitigation strategy for current site uses only, as it is simply impossible to suddenly "switch" to a more ambitious remedial strategy at the last minute, perhaps a couple of years from now, and expect to suddenly comply with the more demanding requirements of residential uses. These are reasonably foreseeable future uses that must, if they are to be preserved, be planned for now.

Both the Porter Cologne Act, which created our modern Water Code, and Resolution 92-49 recognize that conditions of pollution or nuisance also provide the basis for issuance of Orders by the RWQCB (see, Water Code, section 13304(a)). Nuisance is recognized as any condition which presents "...an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property, or unlawfully obstructs the free passage or use, in the customary manner, of any [public right of way or property.]" (see, Civil code, section 3479.) Note that the conceptual proposals for this site discuss the creation of sub-surface parking accommodations. Such construction would encounter conditions of pollution and nuisance, and increased costs, as a result of the excavation and disposal of regulated waste created because of the release of petroleum products. Having created a nuisance on public lands, the Discharger should not now be allowed to remediate only to the level needed to ensure no nuisance from the current use – an asphalt parking lot – but should make plans for the elimination of all those contaminating impacts that will later become inevitable.

Preliminary calculations have been conducted by our technical consultants to determine the groundwater cleanup levels necessary to support unrestricted (residential) use of the City Property overlying the fuel release from MVT. These calculations have been done in accordance with the guidelines published by the County of San Diego Department of Environmental Health (DEH) and widely used in the City and County of San Diego to assess the potential indoor air health risk associated with the accumulation of benzene vapors in a building overlying a gasoline release. DEH defaults were used where parameter values were unknown, and the building was assumed to be slab-on-grade construction with an assumed depth to groundwater of 20 feet.

The attached vapor phase risk calculations reflect a reasonably foreseeable end use consistent with unrestricted use of the City's Property. We request that the Discharger provide similar risk assessment calculations, as part of the requested LNAPL Source Zone Characterization Study, updated to reflect current and projected future site conditions.

Two cases are evaluated for the unrestricted use scenario. (See, Attachment C.) The first assumes that fresh gasoline occurs as LNAPL beneath a building (the mole fraction of benzene in fresh gasoline is assumed to be 0.03). The second is a calculation of the maximum dissolved benzene concentration that would be allowed to remain in groundwater and not represent a significant health risk. Here the DEH criteria are used where a one-in-one million excess cancer risk is judged to be significant.

Calculations for the indoor health risk associated with LNAPL beneath a building demonstrate that a clearly unacceptable risk would occur. The calculated ECR is 4.66 E-3, over 4000 times greater than judged acceptable.

The risk associated with benzene dissolved in groundwater is also significant. A calculation was conducted to determine the maximum benzene concentration that would not trigger a significant health risk from the accumulation of vapors into a structure located above the contaminated groundwater. Based on the potential health risk associated with benzene vapors, the Discharger needs to assess the duration of time that dissolved benzene levels in excess of 12 ug/L will occur in groundwater flowing from MVT. The criteria are based upon the City having unrestricted use of the Property for residential occupancy of a slab-on-grade structure. In addition, the costs caused by the contamination, if remediation is not conducted in a timely manner to levels that permit unrestricted site uses, would effectively be transferred to the public. Land use restrictions caused by the fuel releases would be viewed as an unreasonable burden to the City. Undoubtedly the City would be forced to work to recover the costs from the Dischargers associated with diminution of property values or of direct impact to redevelopment.

Lastly, the Discharger should also include the potential for future site releases as identified in the Risk Management Project Plan for MVT. The potential for future release is certainly foreseeable, and such an event could considerably worsen the result of the health risk calculations at the property adjacent to the MVT.

Additional Assessment Requirements

The Working Group respectfully requests that the RWQCB orders Kinder-Morgan and SFPP, the Discharger, to prepare a LNAPL Source Zone Characterization Report, which should address the following topics:

1. The origin of the LNAPL source zone beneath the Qualcomm Stadium parking lot and the measures taken at MVT to prevent a re-occurrence of such a release.

2. The hydrogeological and multi-phase-flow properties of sediments through which the LNAPL has migrated and in which it is presently trapped beneath the Stadium parking lot.

3. The vertical LNAPL saturation profile of the 'smear zone' at ten locations within the area contained by the dissolved benzene contour of 10 µg/L, as measured during the fourth quarter of 2003. [Saturation is defined as the fraction of the pore volume occupied by LNAPL]

4. The spatial distribution and total volume of LNAPL beneath the parking lot and along the contamination pathway leading back to the manifold at the MVT.

5. A review of enhanced LNAPL recovery technologies that would allow the rapid and complete recovery of the LNAPL source zone defined above. In particular, LFR must discuss the use of steam flooding to remove LNAPL as has been accomplished elsewhere in California and the use of co-solvent flushing by LFR

at the Sages site in Jacksonville FL, which LFR claims reduced the duration of NAPL removal "from decades … to just weeks."

6. A health risk assessment for benzene and other gasoline components for various residential and commercial uses of the land above the LNAPL zone following Site redevelopment.

The Working Group respectfully requests that a Work Plan for such an investigation be submitted for review not later than April 1st, 2004 in order to facilitate field studies beginning later the same month. The Working Group feels that such work would take three to four months to complete, so that plans could be made to move forward with enhanced recovery operations later this year. Only by undertaking such expedited actions, will it be possible for the City to make beneficial use of the Mission Valley aquifer beginning in 2005.

Conclusion

The RWQCB should consider all the options to mitigating groundwater quality at the Mission Valley aquifer, and the resulting impacts on the land uses above it, and approve a process that maximizes the potential for the development and use of these natural resources, both land and water, for the benefit of the community in whose name they are owned. Without consideration of these reasonably foreseeable future uses, the RWQCB would not have a comprehensive means of determining what the appropriate mitigation milestones should be.

The RWQCB should order the Discharger to timely develop adequate and accurate data to assess the consequences of its releases of petroleum products at the Mission Valley Terminal by conducting an LNAPL Source Zone Characterization study. Furthermore, the City recommends that K-M fund a third party performance assessment of the present remediation system [including the air-sparge system] and determine the efficacy of contaminant removal over the next 17 months. Without this data, it is not possible to determine whether appropriate remedial milestones are being met.

The Working Group looks forward to assisting the RWQCB as it considers these challenges, and anticipates future opportunities to provide further focused factual information to the RWQCB during this process.

ATTACHMENT A

"Regulatory History" Excerpt from CH2M Hill Report

5.2.1.2 BTEX and MTBE Contamination in Mission Valley Terminal

A substantial plume containing gasoline (i.e., TPH-g, TPH-d, BTEX, and gasoline oxygenates including MTBE impacts the water quality in the MVGB. This plume is located near the Mission Valley Terminal (MVT in Murphy Canyon.

MVT is a 10.5-acre tank farm that has been in operation since 1962. Petroleum products currently or historically stored at MVT include leaded and unleaded gasoline, gasoline additives, jet fuel, diesel, ethanol, and transmix. Prior and current lessees/operators at MVT include Unocal, Powerine, Buck Petroleum Company, Shell Oil Company, Mobil Oil Corp, Santa Fe Pacific Pipeline Partners, and Texaco Marketing and Refining Inc. MVT is located directly north of Qualcomm Stadium, which is situated upon real property owned by the City.

There have been several unauthorized releases of petroleum products at MVT that have either caused or contributed to contamination at and emanating from the facility. Prior to 1992, the County of San Diego Department of Health Services (DHS) oversaw tank removal activities and/or unauthorized releases of petroleum products involving several of the MVT operators.

5.2.1.3 Texaco

In July 1986, a 2,000-gallon underground storage tank at the Texaco facility, referred to as a slop tank, was decommissioned by excavation and removal because it was found to have a hole. The release from the tank was of unknown quantity and duration. In response, DHS issued an unauthorized release report. In September 1986, a soil vapor survey was conducted by Texaco to evaluate the extent of impacted soil and groundwater, and it was discovered that soil-gas vapor concentrations were higher than background levels. In December 1986, five monitoring wells were installed by Texaco at the southern property boundary.

In September 1987, Texaco also removed a 4,000-gallon underground storage overspill contaminant tank from its fuel-loading rack area. Volatile petroleum hydrocarbons were detected in soil samples collected during tank decommissioning, and the tank was observed to be in poor condition. As a result, five groundwater monitoring wells were installed by Texaco in the fuel-loading rack area in December 1987, and in August 1988, two offsite monitoring wells were installed in the Qualcomm Stadium parking lot.

In May 1989, petroleum hydrocarbons were observed in groundwater from a Texaco monitoring well at the southern boundary of MVT. As of May 1990, Texaco was extracting, treating, and discharging approximately 86,000 gpd of groundwater to a storm drainage channel pursuant to a National Pollutant Discharge Elimination System (NPDES) permit. Based upon the continued presence of petroleum hydrocarbons in groundwater, Texaco installed seven additional monitoring wells to further investigate the extent and distribution of the dissolved-phase petroleum hydrocarbon plume in July 1991. Again, in November 1991, measurable-phase separated hydrocarbons were observed during a quarterly sampling event. One month later, two additional monitoring wells were installed, and during the following month, additional hydrocarbon recovery and treatment was initiated in one of those wells. By March 1992, the RWQCB had authorized Texaco to remediate and discharge 220,000 gpd of treated groundwater into the storm drainage channel.

5.2.1.4 Shell Oil

In April 1987, seven holes were discovered in the bottom of an aboveground storage tank owned and operated by Shell Oil, resulting in an unauthorized release of gasoline of unknown quantity and duration. In addition to tank repair, DHS required groundwater monitoring, and by September 1988, 12 groundwater monitoring wells were installed at the Shell Oil facility. In November 1988, petroleum hydrocarbons were discovered in two of the wells, and Shell Oil commenced removal of free-product from wells until all available, recoverable free-product was removed. In June 1989, Shell Oil installed an additional four monitoring wells. In addition, Shell Oil reported to DHS an unauthorized release of 24 gallons of gasoline additive that was spilled at ground surface between the aboveground storage tank and a monitoring well in March 1991. All affected soil was excavated and disposed offsite.

5.2.1.5 Santa Fe Pacific Pipeline

In October 1987, Santa Fe Pacific Pipeline Partners, LP, installed six groundwater monitoring wells and found phase-separated petroleum hydrocarbons in one well in July 1991. During the first quarter of 1992, Santa Fe Pacific Pipeline Partners conducted a soil-gas survey at the southern tank farm area near the well, revealing a narrow plume of petroleum hydrocarbon contamination in the soil extending south and east. By February 1992, phase-separated petroleum hydrocarbon recovery was commenced at the well.

5.2.1.6 Unocal

In February 1989, Unocal decommissioned by excavation and removal six underground storage tanks that were installed in 1970 for waste oil, new oil, and diesel storage. During the excavation, it was determined that 510 cubic yards of the 1,600 cubic yards of total soil excavated must be disposed offsite as hazardous soil. In response to the presence of hydrocarbon soil encountered during tank decommissioning, DHS issued an "Unauthorized Release Report" in December 1991 and requested a work plan for further characterization of soil and groundwater at the site of the tank excavation.

5.2.1.7 Mobil Oil

In April 1991, Mobil conducted a soil-gas survey near its facilities, and the results indicated moderately high levels of petroleum products near the Mobil loading rack and extending towards an aboveground storage tank. Six groundwater monitoring wells were installed by Mobil in July 1991, and petroleum hydrocarbons were discovered in groundwater and soil.

5.2.1.8 Regional Board Oversight

The County of San Diego oversaw the remediation efforts involving these contamination events until 1992, when the RWQCB issued Cleanup and Abatement Order (CAO) 92-01, and identified Santa Fe Pacific Pipeline, Shell Oil, Mobil Oil Corporation, and Powerine Oil Company as responsible dischargers. The order required the dischargers to begin efforts to identify a means to properly investigate, confine, and remediate the contamination emanating from their facilities. At that time, the plume emanating from the Texaco facility remained under the jurisdiction of the County of San Diego, because it was viewed as already being adequately confined and substantially remediated by the responsible parties. While the total petroleum hydrocarbon plumes under the jurisdiction of the RWQCB have been largely contained to the MVT facility property and its immediate adjacent area, and pump-and-treat remediation and confinement activities continue to date, raising the strong possibility that undetected, unreported leaks have occurred at the MVT facilities subsequent to the spills identified above.

In the fourth quarter of 1996, the RWQCB directed dischargers to monitor and investigate the existence and potential impact of MTBE associated with the plume. Subsequent investigation revealed that a plume of MTBE extended south and southwest of MVT, past the containment and extraction remediation facilities in operation on the northern edge of the Qualcomm Stadium parking lot. As a result of this further investigation, on August 27, 1999, the RWQCB issued Addendum No. 2 to CAO No. 92-01, which indicates that on August 5, 1999, representatives of Equiva Services, LLC, confirmed the presence of MTBE underlying the Texaco facility at the MVT. While previous investigation indicated that the contamination that existed at or near the Texaco facility had been confined, and Texaco had not previously been identified as a responsible party, the RWQCB was no longer certain this was the case. Addendum No. 2 states, The subsurface discharge from the Texaco facility is either co-mingled with or closely associated with the groundwater contamination from the other Mission Valley Terminal facilities." Accordingly, Equiva Services, LLC, as owner of the Texaco facility, was added to CAO 92-01 as a responsible party. In addition, Addendum No. 2 added Equiva Services, LLC as a responsible party based upon its ownership of the Shell Oil facility (Shell was previously identified as a responsible party). In addition, Addendum No. 2 formally identified Kinder Morgan Energy Partners, L.P. as a responsible party, based upon its acquisition of Santa Fe Pacific Partners, L.C. The RWQCB required these dischargers to prepare a revised Corrective Action Plan. Since then, considerable investigation has been conducted by the responsible parties in an attempt to define the horizontal and vertical extent of the MTBE plume for the purpose of devising additional confinement and remediation strategies to be implemented under the revised Corrective Action Plan.

Based on the investigative information to date, the MTBE plume extends southwest of MVT under the Qualcomm Stadium and parking lot, towards the San Diego River. Of substantial concern is the possibility of the MTBE reaching the San Diego River. The reach of the San Diego River near the Mission Valley Terminal is gaining based on a lower water level elevation in the stream than in an adjacent piezometer (CDM, 1999). The extent of the MTBE plume is well defined in the upgradient, and cross-gradient directions (north, east, and northeast); however, the responsible parties continue to investigate the extent of the downgradient direction of the plume towards the San Diego River (south/southwest). The highest reported concentration of MTBE in groundwater is 1,500 parts per billion (ppb) (Kleinfelder, 2000). The state drinking water standard for MTBE is 5 micrograms per liter (μg/L). In addition, an MTBE concentration of 1 ppb was detected in the San Diego River. However, past investigations have not led to a definitive conclusion regarding the extent of the MTBE plume, and further efforts to do so continue.

In 2002, the RWQCB established a leak detection monitoring program for MVT. Installation and testing of the leak detection system for the manifold recently has been completed. In addition, the RWQCB also issued a time schedule order that requires dischargers to propose technically feasible, cleanup milestone dates for the MTBE plume by February 2004.

On March 21, 2003, an arbitrator's decision in a dispute between Kinder Morgan and Texaco/Shell over responsibility for the primary MTBE plume described above, essentially concluded that Kinder Morgan alone was responsible for the plume. The arbitrator and independent expert found overwhelming evidence that concludes that the core MTBE plume emanates from the manifold area of MVT, which is owned and operated by Kinder Morgan and its predecessor Santa Fe Pacific Pipeline, through the Qualcomm Stadium parking lot toward the San Diego River. The arbitrator concluded that neither the Texaco nor the Shell plumes contributed to the core plume, due in large part to superior, timely and continuing efforts to confine and remediate the contamination at or near the facilities they lease from Kinder Morgan. In contrast, the arbitrator detailed a long history of inadequate efforts by Kinder Morgan and Santa Fe Pacific Pipeline to investigate, confine, and remediate the contamination emanating from the MVT manifold area. In response, the RWQCB has requested that the dischargers provide RWQCB with all of the technical materials that were exhibits to the arbitration proceeding. The RWQCB has indicated that it will attempt independently to verify the findings and conclusions from the arbitration proceedings. It is anticipated the RWQCB likely will revise its cleanup and abatement and/or time schedule orders after it investigates the arbitrator's findings.

The City is actively participating in the regulatory process for this facility and will continue to do so during the implementation of its framework for long-term management of the resource.

5.2.2 Database Review and Identification of Threats/Constraints

Database Searches

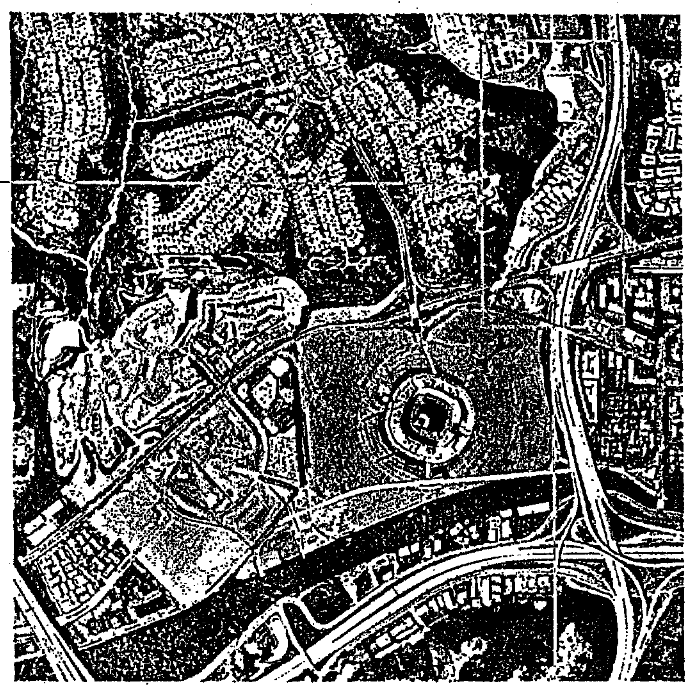
Multiple environmental tracking databases were reviewed for listings in the SDRS, its adjacent groundwater basins, and the surrounding areas by Environmental Data Resources, Inc. (EDR), of Southport, Connecticut. The database search included federal, state, and supplemental records identified by the American Society for Testing and Materials (ASTM) as well as San Diego County and California RWQCB (Region 9) databases. The ASTM standards that identify environmental databases were established to define good commercial and customary practice in the United States for conducting environmental site assessments of properties to evaluate the presence of any hazardous substances or petroleum products under conditions that would indicate an existing or past release or a material threat of a release. These standards satisfy the appropriate inquiry or due diligence requirement needed to qualify for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) innocent landowner defense. A summary of the facilities detected are presented in Table 5-4 and the site locations are shown in Figure 5-5. A list and brief description of each of the databases searched are presented below.

Federal Databases

CERCLIS (Comprehensive Environmental Response, Compensation, and Liability Information System). CERCLIS contains data on potential hazardous waste sites that have been reported to EPA by states, municipalities, private companies, and private persons, pursuant to Section 103 of CERCLA. CERCLIS contains sites that are either proposed to be or are on the National Priorities List (NPL) and sites that are in the screening and assessment phase for possible inclusion on the NPL.

ATTACHMENT B

Site Concept Proposals

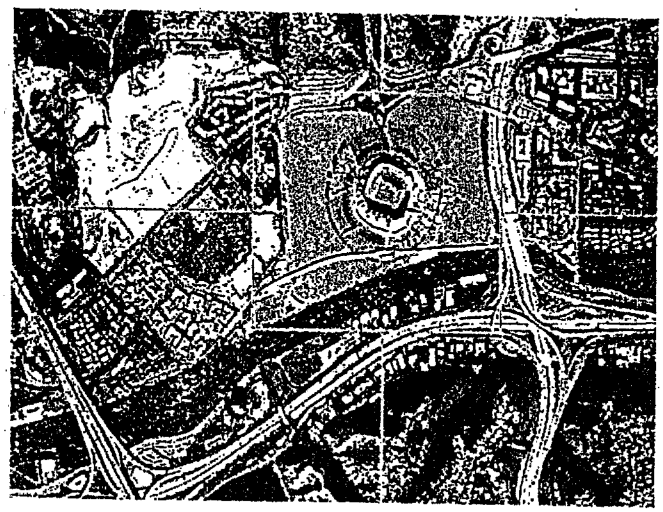


INTRODUCTION

An attractive, vibrant, urban mixed-use village is envisioned for the Stadium Site. Based on a street grid similar to Centre City, these illustrative concepts each incorporate all of the principles of the **City of Villages** resulting in a pedestrian oriented village focused on the existing and future transit system.

In the spirit of our great livable urban centers, uses are mixed vertically with retail and office spaces at the street level and residences above. A festive retail neighborhood will surround much of the stadium itself, obscuring and integrating this large structure into the village fabric.

Public parks are fully integrated into each plan, responding to the recreation needs of residents of Mission Valley and Serra Mesa along with the future vision of the San Diego River Park. Each of the three development concepts relies on a unique arrangement of park space to determine its overall urban form.



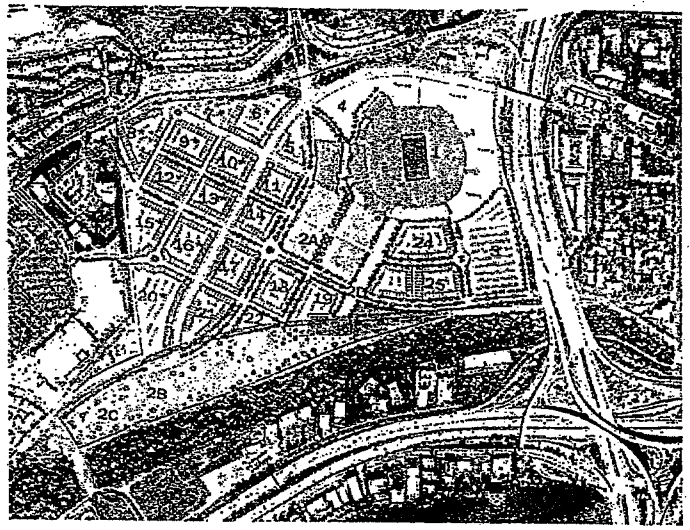
Pedestrian and vehicular linkages to the surrounding community as well as the broad pedestrian esplanade joining the stadium and the trolley station make each of these plans work well with local and regional infrastructure.

A mixture of residential housing concepts including affordable, senior and workforce housing will create a livable environment for all citizens of San Diego who wish to live in this unique environment. The workforce housing concept may also be beneficial to those who attend San Diego State University located just a few trolley stops away.

Living and working in this environment will be much like that of the Core of North University City, Little Italy, Cortel Hill, or the emerging East Village. This type of development supports the satisfying urban lifestyle that has become so desirable in San Diego.

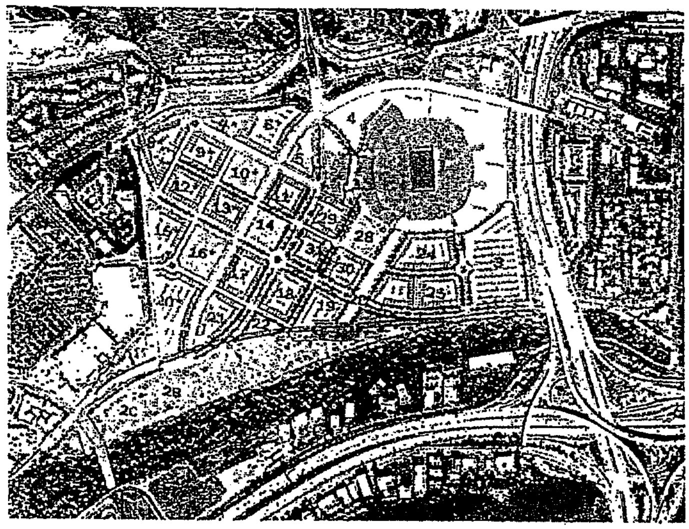
CENTRAL PARK CONCEPT

A 10-acre active park is the focus of this concept. Located at the exact footprint of the existing stadium, this park will provide recreation opportunities for village residents and the surrounding communities as well. The central park will be connected to the active portion of the San Diego River Park with several short pedestrian links resulting in 30-acres of community recreation space. The park also serves as a foreground for the stadium and provides an opportunity for event parking.



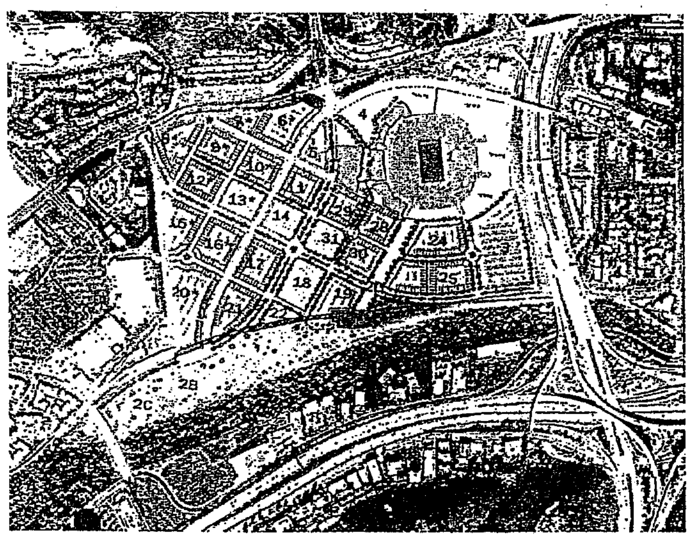
DISTRIBUTED PARK CONCEPT

Dispersing the 10-acre active park in to 4 smaller parks serving as the focus of individual neighborhoods results in an individualized sense of community and a balanced distribution of open space. This concept, unique in San Diego, results in a village that is truly based on open space and parks with opportunities for recreation virtually at every doorstep. These neighborhood parks are similar to those found in London making it a very livable part of the city.



LINEAR PARK CONCEPT

Making a direct connection to the San Diego River Park with the Village Park is the strength of this concept. In a truly unique approach, recreation and public activities form the core of this Village. The smooth transition between these parks will result in a continuous experience and opportunity for residents and visitors. These 30 park acres will be easily accessible from the surrounding communities due to the smooth transition of village streets with neighboring traffic patterns and public transit.



This concept fully integrates the stadium itself into the fabric of the Village resulting in a seamless living environment. The retail and support activities that surround the stadium will be available to support the community everyday, not just event days. While this feature is part of each concept, it is more fully implemented with the Linear Park Concept.

Stadium Site Redevelopment Concept
Summary Development Program

Based on Central Park Concept
August 1, 2003

Residential

Market Units	5,153
Affordable Non-Senior	700
Affordable Senior	200
TOTAL Residential Units	6,053

Retail

TOTAL Retail	373,000 s.f.

Office

TOTAL Office	180,000 s.f.

Hotel

TOTAL Hotel	400 Rooms

Park

TOTAL Park	29.17 acres

Parking

Stadium/Event Parking	6,750 spaces
Development Parking	12,019 spaces
TOTAL Parking	18,769 spaces

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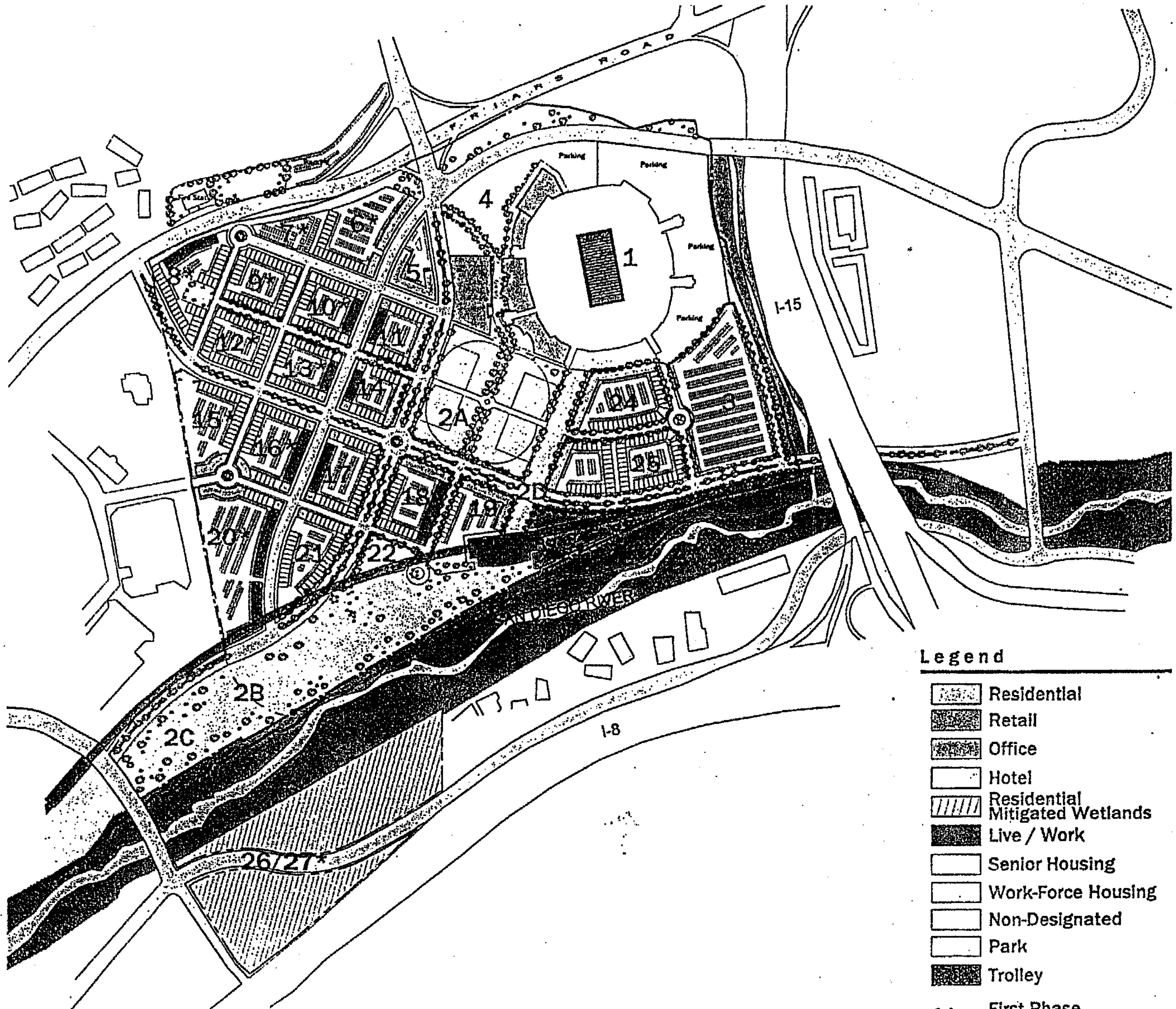

Stadium Site
Development Concept

Central Park Concept

Parcel Number	Use	Acre(s)	Town-homes	Dwelling Units	Num. of Floors	Total (d.u.)
1	New Stadium	22.27				
2-A	Jack Murphy Park	8.95				
2-B	River Park/Comm. Park	11.13				
2-C	River Park/Design Park	8.03				
2-D	Esplanade	2.27				
3	Office/Hotel/Parking	6.75				
4	Res./Retail/Parking	10.88		244	4	244
5	Office (80,000 sf.)	1.31				
6*	Res./Retail/Parking	3.47	19	88	4	107
7*	Work-Force Housing	1.19		350	4	350
8*	Residential Mixed Use	2.96	36	216	3	252
9*	Residential	2.20	39	232	4	271
10*	Residential Mixed Use	2.09	25	224	4	249
11	Residential Mixed Use	1.91	13	242	2/8	255
12*	Residential	2.02	38	224	4	262
13*	Residential Mixed Use	1.95	25	212	4	237
14	Residential Mixed Use	1.77	13	234	2/8	247
15*	Residential Mixed Use	2.98	20	171	3	191
16*	Residential Mixed Use	2.80	25	268	4	293
17	Residential Mixed Use	2.59	30	298	2/8	328
18	Residential Mixed Use	2.48	19	306	6	325
19	Work-Force/Senior Retail (20,000 sf.)	2.53		350	4	350
20*	Residential Mixed Use	4.71	6	279	4	285
21	Residential Mixed Use	3.15	33	314	2/6	381
22	Park/Event Parking	1.06				
23	NOT USED					
24	Residential Mixed Use	3.17	24	330	2/8	354
25	Residential Mixed Use	4.25	64	508	2/6	572
26/27*	Residential Mixed Use/ Potential Wetland Mitigation	16.97		500		500
					TOTAL	6053

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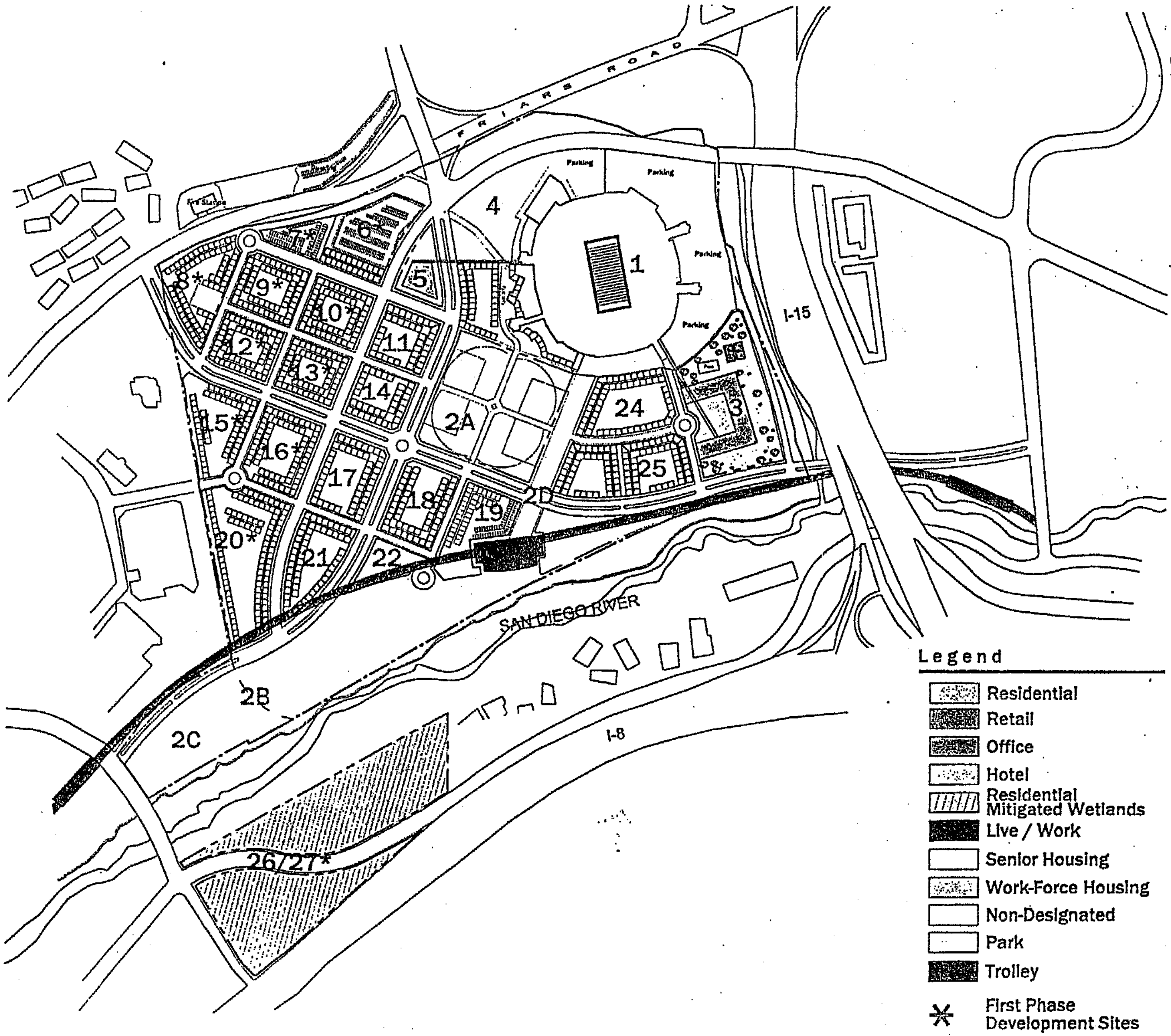
Central Park Concept - Developable Acreage Study - Ground Level Plan

Stadium Site Redevelopment Concept - DRAFT

August 1, 2003

*Conceptual Master Planning. For illustrative purposes only - configuration subject to change.



Stadium Site
Development Concept

·Central Park Concept

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2-B	River Park/Comm. Park	11.13				
2-C	River-Park/Design Park	8.03				
2-D	Esplanade	2.27				
3	Office/Hotel/Parking	6.75				
4	Res./Retail/Parking	10.88		244	4	244
5	Office (80,000 sf.)	1.31				
6*	Res./Retail/Parking	3.47	19	88	4	107
7*	Work-Force Housing	1.19		350	4	350
8*	Residential Mixed Use	2.96	36	216	3	252
9*	Residential	2.20	39	232	4	271
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					TOTAL	6053

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Central Park Concept - Developable Acreage Study - Upper Level Plan

Stadium Site Redevelopment Concept - DRAFT

August 1, 2003

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Stadium Site Redevelopment Concept
Area Calculations for Developable Area

Central Park Concept
Based on August 1st Plan

Parcel	Use	Area: Square Feet	Area: Acres	Pkg./Floor	# Flrs./Pkg.	Total Pkg.	D.U.	Market	Afford.	Afford/ W-Force	Afford/ Senior	Res. Flrs.	Retail Sq.Ft.	Office Sq.Ft.	Work/Live	Hotel Rms.
1	New Stadium	970,000	22.27	600	1	600							0			
Total		970,000	22.27	600		600	0	0	0	0	0	0	0	0	0	0
2-A	Jack Murphy Park	390,000	8.95	1250	1	1250										
2-B	River Park/Comm. Park	485,000	11.13	1250	1	1250										
2-C	River Park/ Design Park	350,000	8.03													
2-D	Esplanade	99,000	2.27													
Total		1,324,000	30.39	2500		2500	0	0	0	0	0	0	0	0	0	0
3	Office/Hotel/Parking	294,000	6.75	1000	4	4000								100,000		400
4	Res./Retail/Parking	474,000	10.88	950	1	950	244	244				4	181,000			
5	Office	57,000	1.31	135	2	270								80,000		
*6	Res./Retail/Parking	151,000	3.47	320	3	960	107	107				4	22,000			
*7	Work-Force Housing	52,000	1.19	60	3	180	350			350		4				
*8	Residential Mixed Use	129,000	2.96	115	2	230	252	252				3			18,000	
*9	Residential	96,000	2.20	150	3	450	271	171	100			4				
*10	Residential Mixed Use	91,000	2.09	150	3	450	249	149	100			4	5,000		9,500	
11	Residential Mixed Use	83,000	1.91	150	3	450	255	255				8	20,000		9,500	
*12	Residential	88,000	2.02	165	3	495	262	262				4				
*13	Residential Mixed Use	85,000	1.95	150	3	450	237	237				4	5,000		8,500	
14	Residential Mixed Use	77,000	1.77	150	3	450	247	247				8	18,000		8,500	
15	Residential Mixed Use	130,000	2.98	235	2	470	191	191				3	9,000			
*16	Residential Mixed Use	122,000	2.80	290	3	870	293	293				4	10,000		15,000	
17	Residential Mixed Use	113,000	2.59	290	3	870	328	328				8	5,000		14,000	
18	Residential Mixed Use	108,000	2.48	255	3	765	325	325				6	13,000		17,000	
19	W-Force/Senior/Retail	110,000	2.53	150	3	450	350			150	200	4	20,000			
*20	Residential Mixed Use	205,000	4.71	416	2	832	285	285				3	15,000		33,000	
21	Residential Mixed Use	137,000	3.15	247	3	741	381	381				6	5,000		21,000	
22	Park / Event Parking	46,000	1.06	150	1	150										
23	NOT USED		0.00			0										
24	Residential Mixed Use	138,000	3.17	207	3	621	354	354				8	31,000			
25	Residential Mixed Use	185,000	4.25	245	3	735	572	572				6	14,000			
Total		2,971,000	68.20	5,980		15,839	5,553	4,653	200	500	200		373,000	180,000	154,000	400
Other	Residual Spaces	166,000	3.81													
Other	Streets / R.O.W	1,800,000	41.32													
Total			45.13	0		0	0	0		0	0		0	0	0	0
Overall Total		5,265,000	166.00	9,080		18,939	5,553	4,653	200	500	200		373,000	180,000	154,000	400
*26/27	Res./Mixed Use/Open	739,000	16.97				500									
		739,000	16.97	0			500								0	0

*First Phase Devlopment

DRAFT

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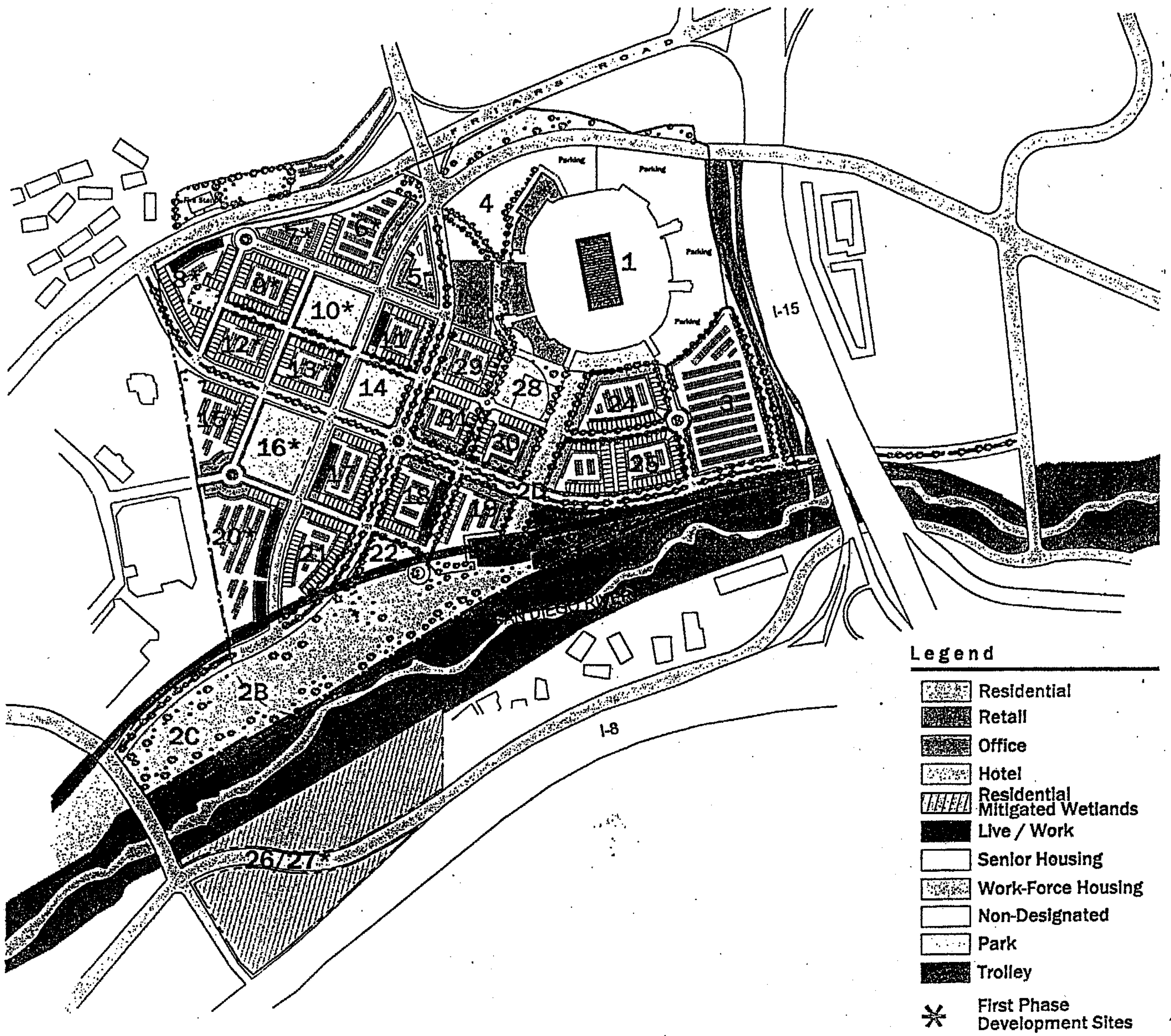

Stadium Site
Development Concept

Distributed Park Concept

Parcel Number	Use	Acre(s)	Town-homes	Dwelling Units	Num. of Floors	Total (d.u.)
1	New Stadium	22.27				
2-A	NOT USED					
2-B	River Park/Comm. Park	11.13				
2-C	River Park/Design Park	8.03				
2-D	Esplanade	2.27				
3	Office/Hotel/Parking	6.75				
4	Res./Retail/Parking	10.88		244	4	244
5	Office (80,000 sf.)	1.31				
6*	Res./Retail/Parking	3.47	19	88	4	107
7*	Work-Force Housing	1.19		350	4	350
8*	Residential Mixed Use	2.96	36	216	3	252
9*	Residential	2.20	39	232	4	271
10*	Park/Event Parking	2.09				
11	Residential Mixed Use	1.91	13	242	2/8	255
12*	Residential	2.02	38	224	4	262
13*	Residential Mixed Use	1.95	25	212	4	237
14	Park/Event Parking	1.77				
15*	Residential Mixed Use	2.98	20	171	3	191
16*	Park/Event Parking	2.80				
17	Residential Mixed Use	2.59	30	298	2/8	328
18	Residential Mixed Use	2.48	19	306	6	325
19	Work Force/Senior / Retail (20,000 sf.)	2.53		350	4	350
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22	Park/Event Parking	1.06				
23	NOT USED					
24	Residential Mixed Use	3.17	24	330	2/8	354
25	Residential Mixed Use	4.25	64	508	2/6	572
26/27*	Residential Mixed Use/ Potential Wetland Mitigation	16.97		500		500
28	Park/Event Parking	2.00				
29	Residential Mixed Use	1.95	25	232	2/8	257
30	Residential Mixed Use	1.97	14	194	2/6	208
31	Residential Mixed Use	1.91	14	194	2/6	208
					TOTAL	5937

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Distributed Park Concept - Developable Acreage Study - Ground Level Plan

Stadium Site Redevelopment Concept - DRAFT

August 1, 2003

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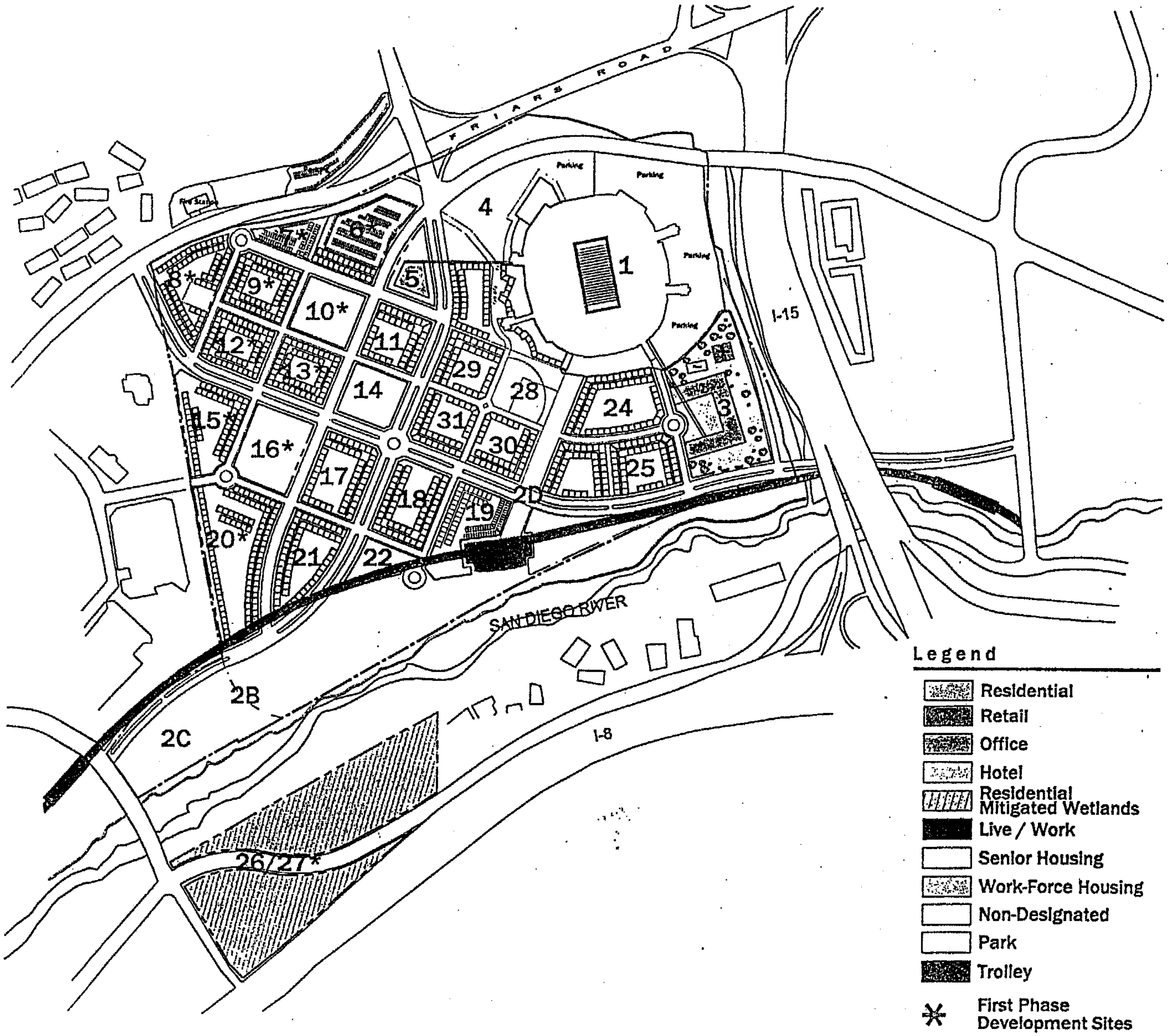

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					TOTAL	5937

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Distributed Park Concept - Developable Acreage Study - Upper Level Plan

Stadium Site Redevelopment Concept - DRAFT

August 1, 2003

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Stadium Site Redevelopment Concept
Area Calculations for Developable Area

Distributed Park Concept
Based on August 1st Plan

Parcel	Use	Area: Square Feet	Area: Acres	Pkg./Floor	# Flrs./Pkg.	Total Pkg.	D.U.	Market	Afford.	Afford/ W-Force	Afford/ Senior	Res. Flrs.	Retail Sq.Ft.	Office Sq.Ft.	Work/Live	Hotel Rms.
1	New Stadium	970,000	22.27	600	1	600							0			
Total		970,000	22.27	600		600	0	0	0	0	0	0	0	0	0	0
2-A	NOT USED															
2-B	River Park/Comm. Park	485,000	11.13	1250	1	1250										
2-C	River Park/Design Park	350,000	8.03													
2-D	Esplanade	99,000	2.27													
Total		934,000	21.44	1250		1250	0	0	0	0	0	0	0	0	0	0
3	Office/Hotel/Parking	294,000	6.75	1000	4	4000								100,000		400
4	Res./Retail/Parking	474,000	10.88	950	1	950	244	244				4	150,000			
5	Office	57,000	1.31	135	2	270								80,000		
*6	Res./Retail/Parking	151,000	3.47	320	3	960	107	107				4	21,000			
*7	Work-Force Housing	52,000	1.19	60	3	180	350			350		4				
*8	Residential Mixed Use	129,000	2.96	115	2	230	252	252				3			11,000	
*9	Residential	96,000	2.20	150	3	450	271	171	100			4				
*10	Park/Event Parking	91,000	2.09	275	1	275										
11	Residential Mixed Use	83,000	1.91	150	3	450	255	255				8	14,000		7,500	
*12	Residential	88,000	2.02	165	3	495	262	162	100			4				
13	Residential Mixed Use	85,000	1.95	150	3	450	237	237				4	4,000		8,000	
14	Park/Event Parking	77,000	1.77	225	1	225										
15	Residential Mixed Use	130,000	2.98	235	2	470	191	191				3	8,000			
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17	Residential Mixed Use	113,000	2.59	290	3	870	328	328				8	4,000		14,000	
18	Residential Mixed Use	108,000	2.48	255	3	765	325	325				6	10,000		14,000	
19	W-Force/Senior/Retail	110,000	2.53	150	3	450	350			150	200	4	20,000			
*20	Residential Mixed Use	205,000	4.71	416	2	832	285	285				3	15,000		34,000	
21	Residential Mixed Use	137,000	3.15	247	3	741	381	381				6	2,000		12,000	
22	Park/Event Parking	46,000	1.06	135	1	135										
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24	Residential Mixed Use	138,000	3.17	207	3	621	354	354				8	30,000			
25	Residential Mixed Use	185,000	4.25	245	3	735	572	572				6	15,000			
28	Park/Event Parking	87,000	2.00	250	1	250										
29	Residential Mixed Use	85,000	1.95	120	3	360	257	257				8	14,000			
30	Residential Mixed Use	86,000	1.97	130	3	390	208	208				6	27,000			
31	Residential Mixed Use	83,000	1.91	130	3	390	208	208				6	26,000			
Total		3,312,000	76.03	6,880		16,319	5,437	4,537	200	500	200		360,000	180,000	100,500	400
Other	Residual Spaces	166,000	3.81													
Other	Streets / R.O.W.	1,849,000	42.45													
Total			46.26	0		0	0	0		0	0		0	0	0	0
Overall Total		5,216,000	166.00	8,730		18,169	5,437	4,537	200	500	200		360,000	180,000	100,500	400
*26/27	Res/Mixed Use/Open	739,000	16.97			900	500	500								
		739,000	16.97	0		900	500	500							0	0

*First Phase Devlopment

DRAFT

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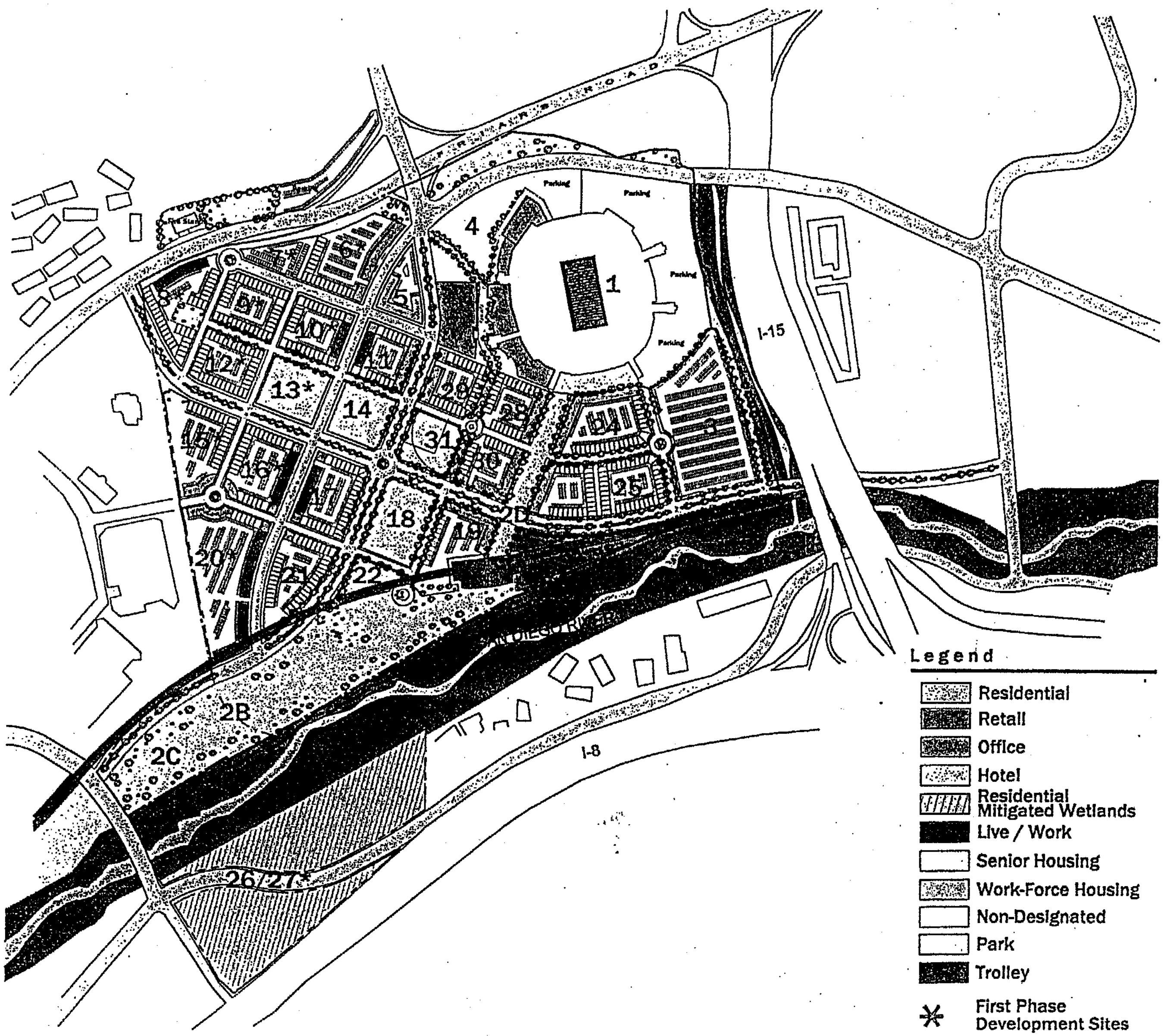

Stadium Site
Development Concept

Linear Park Concept

Parcel Number	Use	Acre(s)	Town-homes	Dwelling Units	Num. of Floors	Total (d.u.)
1	New Stadium	22.27				
2-A	NOT USED					
2-B	River Park/Comm. Park	11.13				
2-C	River Park/Design Park	8.03				
2-D	Esplanade	2.27				
3	Office/Hotel/Parking	6.75				
4	Res./Retail/Parking	10.88		244	4	244
5	Office (80,000 sf.)	1.31				
6*	Res./Retail/Parking	3.47	19	88	4	107
7*	Work-Force Housing	1.19		350	4	350
8*	Residential Mixed Use	2.96	36	216	3	252
9*	Residential	2.20	39	232	4	271
10*	Residential Mixed Use	2.09	25	224	4	249
11	Residential Mixed Use	1.91	13	242	2/8	255
12*	Residential	2.02	38	224	4	262
13*	Park/Event Parking	1.95				
14	Park/Event Parking	1.77				
15*	Residential Mixed Use	2.98	20	171	3	191
16*	Residential Mixed Use	2.80	25	268	4	293
17	Residential Mixed Use	2.59	30	298	2/8	328
18	Park/Event Parking	2.48				
19	Work Force/Senior/ Retail (20,000 sf.)	2.53		350	4	350
20*	Residential Mixed Use	4.71	6	279	4	285
21	Residential Mixed Use	3.15	33	314	2/6	381
22	Park/Event Parking	1.06				
23	NOT USED					
24	Residential Mixed Use	3.17	24	330	2/8	354
25	Residential Mixed Use	4.25	64	508	2/6	572
26/27*	Residential Mixed Use/ Potential Wetland Mitigation	16.97		500		500
28	Residential Mixed Use	2.00	24	232	2/8	256
29	Residential Mixed Use	1.95	25	232	2/8	257
30	Residential Mixed Use	1.97	14	192	2/6	206
31	Park/Event Parking	1.91				
					TOTAL	5963

Linear Park Concept - Developable Acreage Study - Ground Level Plan

Stadium Site Redevelopment Concept - DRAFT

*Conceptual Master Planning. For illustrative purposes only - configuration subject to change.

August 1, 2003

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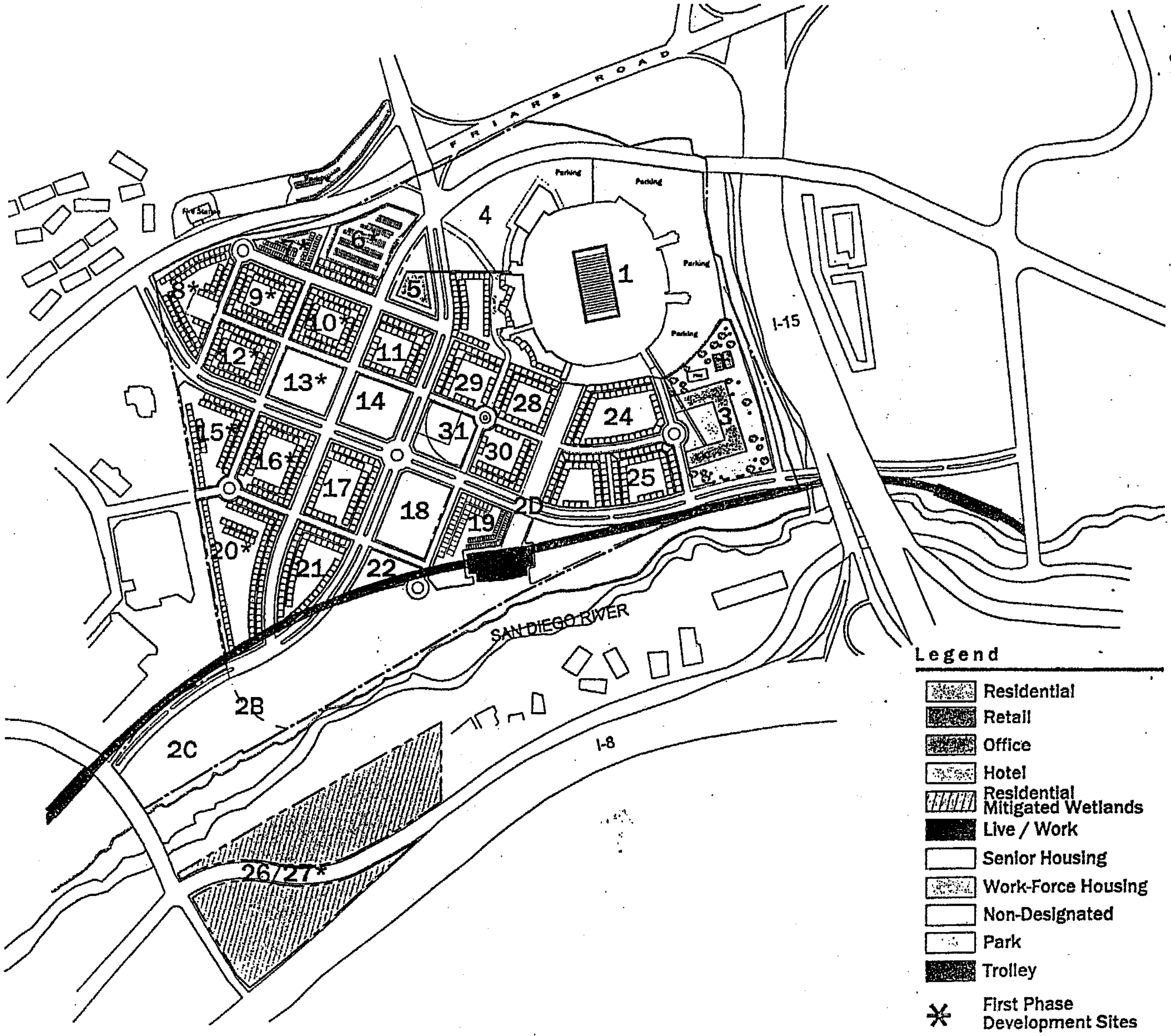

Stadium Site
Development Concept

Linear Park Concept.

Parcel Number	Use	Acre(s)	Town-homes	Dwelling Units	Num. of Floors	Total (d.u.)
1	New Stadium	22.27				
2-A	NOT USED					
2-B	River Park/Comm. Park	11.13				
2-C	River Park/Design Park	8.03				
2-D	Esplanade	2.27				
3	Office/Hotel/Parking	6.75				
4	Res./Retail/Parking	10.88		244	4	244
5	Office (80,000 sf.)	1.31				
6*	Res./Retail/Parking	3.47	19	88	4	107
7*	Work-Force Housing	1.19		350	4	350
8*	Residential Mixed Use	2.96	36	216	3	252
9*	Residential	2.20	39	232	4	271
10*	Residential Mixed Use	2.09	25	224	4	249
11	Residential Mixed Use	1.91	13	242	2/8	255
12*	Residential	2.02	38	224	4	262
13*	Park/Event Parking	1.95				
14	Park/Event Parking	1.77				
15*	Residential Mixed Use	2.98	20	171	3	191
16*	Residential Mixed Use	2.80	25	268	4	293
17	Residential Mixed Use	2.59	30	298	2/8	328
18	Park/Event Parking	2.48				
19	Work Force/Senior/ Retail (20,000 sf.)	2.53		350	4	350
20*	Residential Mixed Use	4.71	6	279	4	285
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29	Residential Mixed Use	1.95	25	232	2/8	257
30	Residential Mixed Use	1.97	14	192	2/6	206
31	Park/Event Parking	1.91				
					TOTAL	5963

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Linear Park Concept - Developable Acreage Study - Upper Level Plan

Stadium Site Redevelopment Concept - DRAFT

August 1, 2003

*Conceptual Master Planning. For illustrative purposes only - configuration subject to change.

Stadium Site Redevelopment Concept
Area Calculations for Developable Area

Linear Park Concept
Based on August 1st Plan

Parcel	Use	Area: Square Feet	Area: Acres	Pkg./Floor	# Flrs./Pkg.	Total Pkg.	D.U.	Market	Afford.	Afford/ W-Force	Afford/ Senior	Res. Flrs.	Retail Sq.Ft.	Office Sq.Ft.	Work/Live	Hotel Rms.
1	New Stadium	970,000	22.27	600	1	600							0			
Total		970,000	22.27	600		600	0	0	0	0	0	0	0	0	0	0
2-A	NOT USED															
2-B	River Park/Comm. Park	485,000	11.13	1250	1	1250										
2-C	River Park/Design Park	350,000	8.03													
2-D	Esplanade	99,000	2.27													
Total		934,000	21.44	1250		1250	0	0	0	0	0	0	0	0	0	0
3	Office/Hotel/Parking	294,000	6.75	1000	4	4000								100,000		400
4	Res./Retail/Parking	474,000	10.88	950	1	950	244	244				4	150,000			
5	Office	57,000	1.31	135	2	270								80,000		
*6	Res./Retail/Parking	151,000	3.47	320	3	960	107	107				4	21,000			
*7	Office	52,000	1.19	140	2	280										
*8	Residential Mixed Use	129,000	2.96	115	2	230	252	252				3			11,000	
*9	Residential	96,000	2.20	150	3	450	271	171	100			4				
*10	Residential Mixed Use	91,000	2.09	275	1	275	249	249				4	5,000		10,000	
11	Residential Mixed Use	83,000	1.91	150	3	450	255	255				8	14,000		7,500	
*12	Residential	88,000	2.02	165	3	495	262	162	100			4				
13	Park/Event Parking	85,000	1.95	240	1	240										
14	Park/Event Parking	77,000	1.77	225	1	225										
15	Residential Mixed Use	130,000	2.98	235	2	470	191	191				3	8,000			
*16	Residential Mixed Use	122,000	2.80	290	3	870	293	293				4	10,000		15,000	
17	Residential Mixed Use	113,000	2.59	290	3	870	328	328				8	4,000		14,000	
18	Park/Event Parking	108,000	2.48	310	1	310										
19	W-Force/Senior/Retail	110,000	2.53	150	3	450	350			150	200	4	20,000			
*20	Residential Mixed Use	205,000	4.71	416	2	832	285	285				3	15,000		34,000	
21	Residential Mixed Use	137,000	3.15	247	3	741	381	381				6	2,000		12,000	
22	Park/Event Parking	46,000	1.06	135	1	135										
23	NOT USED															
24	Residential Mixed Use	138,000	3.17	207	3	621	354	354				8	30,000			
25	Residential Mixed Use	185,000	4.25	245	3	735	572	572				6	15,000			
28	Residential Mixed Use	87,000	2.00	125	1	125	256	256				8	14,000			
29	Residential Mixed Use	85,000	1.95	120	3	360	257	257				8	14,000			
30	Residential Mixed Use	86,000	1.97	120	3	360	206	206				6	27,000			
31	Park/Event Parking	83,000	1.91	235	1	235										
Total		3,312,000	76.03	6,990		15,939	5,113	4,563	200	150	200		349,000	180,000	103,500	400
Other	Residual Spaces	166,000	3.81													
Other	Streets / R.O.W.	1,849,000	42.45													
Total			46.26	0		0	0	0		0	0		0	0	0	0
Overall Total		5,216,000	166.00	8,840		17,789	5,113	4,563	200	150	200		349,000	180,000	103,500	400
*26/27	Res. Mixed Use/Open	739,000	16.97			900	500	500								
		739,000	16.97	0		900	500	500							0	0

*First Phase Devlopment

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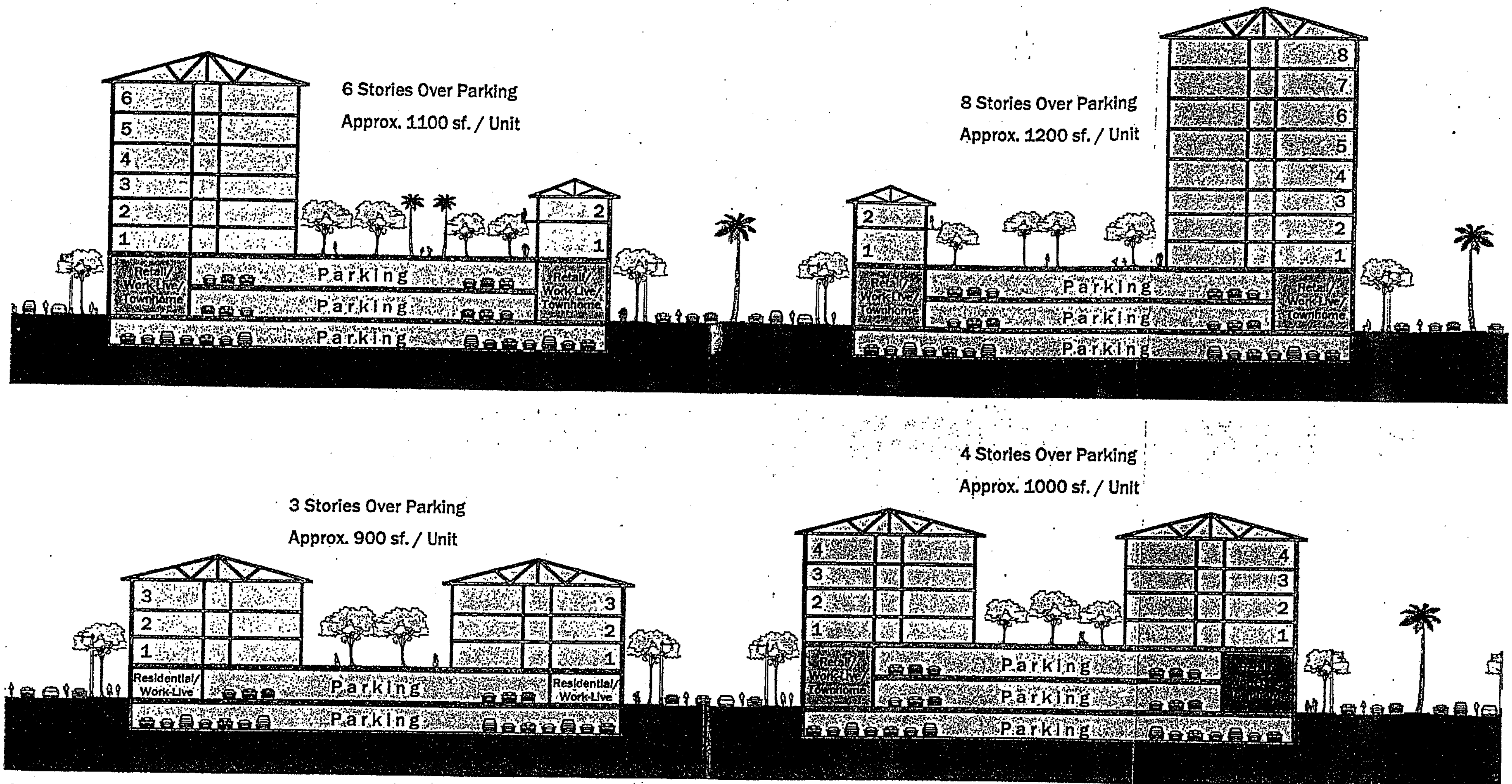

Legend

- Residential
- Retail
- Live / Work

0 25 50 100 FEET

Stadium Site Redevelopment Concept - DRAFT

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August 1, 2003

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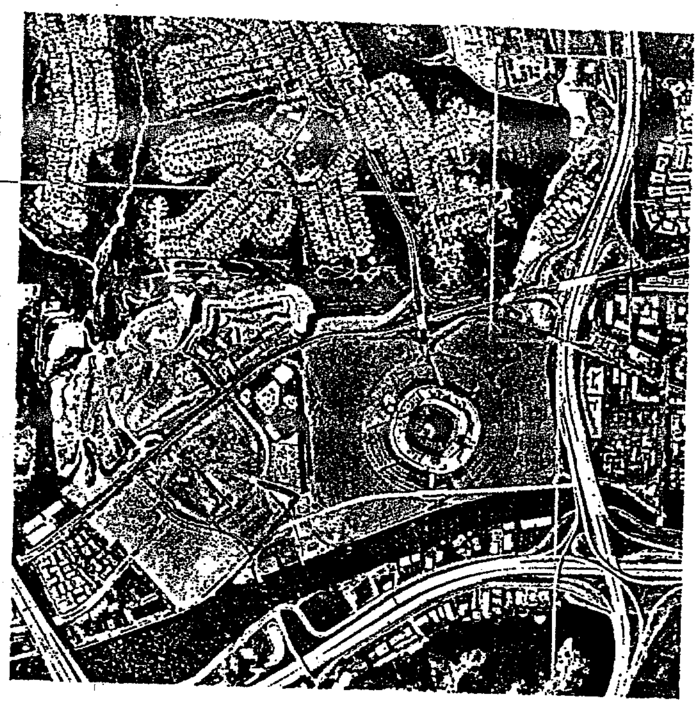
ATTACHMENT C

Representative Human Health Risk Assessments



Case Name:

CHEMICAL OF CONCERN:

Enter Chemical Name = benzene

C11 benzene
C12 benzo(a)pyrene
C13 carbon tetrachloride
C14 chlorobenzene
C15 chloroethane (ethyl chloride)
C16 chloromethane (methyl chloride)
C17 1,2-dichlorobenzene
C18 1,3-dichlorobenzene
C19 1,4-dichlorobenzene
C20 1,1-dichloroethene (1,1-DCE)
C21 trans-1,2-dichloroethene
C22 1,1-dichloroethane (1,1-DCA)
C23 1,2-dichloroethane (1,2-DCA)

E11 dichloromethane (methylene chloride)
E12 ethylbenzene
E13 naphthalene
E14 methyl tertiary butyl ether (MTBE)
E15 tetrachloroethene (PCE)
E16 toluene
E17 1,1,1-trichloroethane
E18 1,1,2-trichloroethane
E19 trichloroethene (TCE)
E20 trichloromethane (chloroform)
E21 vinyl chloride
E22 xylene

Chemical Mixture (if app.) =

C27 Gasoline
C28 Kerosene
C29 Diesel

E27 Fuel Oil
E28 Waste Oil

If compound is not listed then data must be entered into the site-specific field.

SITE SPECIFIC INFORMATION			Site-Specific	Value Used
Mole fraction	dimensionless	MF		0.0000
Temperature	K	T		293
Water concentration (chemical)	ug/l	C_w	11.85	11.85
Soil concentration (chemical)	mg/kg	C_t		0
Soil concentration (TPH/TRPH)	mg/kg	C_t		0
Soil gas concentration (measured)	mg/m3 (ug/l)	C_{sg}(m)		0
Depth of contamination or Soil Gas	m	X	6.097560976	6.097560976

CHEMICAL PROPERTIES			Site Specific	Value Used
Henry's Law Constant	dimensionless	H		0.23
Vapor pressure	atm	VP		0.13
Molecular weight (chemical)	mg/mole	MW		78,110
Molecular weight (mixture)	mg/mole	MW(m)		#N/A
Universal gas constant	atm-m3/mole-K	R	XXXXXXXXXX	8.20E-05
Diffusion coefficient in air	cm2/sec	D_a		0.088
Organic carbon partitioning coef.	cm3/gm	K_{oc}		62
SOIL PROPERTIES				
Total porosity	dimensionless	θ		0.3
Air-filled porosity	dimensionless	θ_a		0.2
Water-filled porosity	dimensionless	θ_w	XXXXXXXXXX	0.1
Bulk density (dry)	gm/cc	r_b		1.8
Weight fraction of organic carbon	dimensionless	foc		0.01
BUILDING SPECIFICATIONS				
Floor area of building	m2	A		1
% of floor area that flux occurs	dimensionless			100%
Interior Height of building	m	R_h		2.44
Exchange rate of air	exchanges/hr	E		0.83
Slab Attenuation factor	dimensionless	S_b		0.1
OUTDOOR AIR COMPONENT				
Downwind contamination length	m	L		0
Wind speed	m/hr	u		16000
Height of building openings	m	h		2
EXPOSURE SCENARIO Default values are for Industrial Uses				
Body weight	kg	BW		70
Inhalation rate	m3/day	IR		20
Exposure duration	yrs	ED	70	70
Hours per day	hr/day		24	24
Days per week	days/week		7	7
Weeks per year	weeks/yr			50
HEALTH RISK FACTORS				
Reference dose	mg/kg-day	RfD		0.0017
Slope factor (potency)	1/(mg/kg-day)	SF		0.1

Case Name: Mission Valley Terminal

Chemical: benzene

Variable Descriptions **Units**

CALCULATION OF SOIL GAS CONCENTRATION

A. SOURCE - Free Product/Soil>100mg/kg.

Mole fraction	MF	=	3.00E-02	dimensionless
Molecular weight	MW	=	7.81E+04	mg/mole
Vapor pressure	VP	=	1.30E-01	atm
Universal gas constant	R	=	8.20E-05	atm-m3/mole-K
Temperature	T	=	2.93E+02	K
Calculated soil gas concentration	$C_{sg}(fp)$	=	**1.27E+04**	mg/m3

B. SOURCE - Groundwater

Water contamination level	C_w	=	0.00E+00	ug/l
Henry's Law Constant	H	=	2.30E-01	dimensionless
Calculated soil gas concentration	$C_{sg}(gw)$	=	0.00E+00	mg/m3

C. SOURCE - Soil < 100 mg/kg

Soil contamination level	C_t	=	0.00E+00	mg/kg
Henry's Law Constant	H	=	2.30E-01	dimensionless
Bulk density (dry)	ρ_b	=	1.80E+00	gm/cc
Air-filled porosity	θ_a	=	2.00E-01	dimensionless
Water-filled porosity	θ_w	=	1.00E-01	dimensionless
Soil/water distribution coef.	K_d	=	6.20E-01	cm3/gm
Calculated soil gas concentration	$C_{sg}(s)$	=	0.00E+00	mg/m3

D. SOURCE - Measured Soil Gas

Measured soil gas concentration	$C_{sg}(m)$	=	0.00E+00	mg/m3 (ug/l)

E. SOIL GAS CONCENTRATION USED IN RISK CALCULATIONS >>>> **1.27E+04 mg/m3**

DIFFUSIVE TRANSPORT UPWARD IN UNSATURATED ZONE

Total porosity	θ	=	3.00E-01	dimensionless
Air-filled porosity	θ_a	=	2.00E-01	dimensionless
Diffusion coefficient in air	D_a	=	8.80E-02	cm2/sec
Effective diffusion coefficient	D_e	=	4.60E-03	cm2/sec
Depth of contamination or Csg	X	=	6.10E+00	m
Calculated Flux	F_x	=	3.44E+00	mg/m2-hour

Case Name: Mission Valley Terminal

CALCULATING VAPOR CONCENTRATION IN BUILDING

A. INDOOR AIR COMPONENT				
Floor area of building	A	=	1.00E+00	m2
% of floor area that flux occurs			1.00E+00	dimensionless
Slab Attenuation factor	S_b	=	1.00E-01	dimensionless
Flux area within building	Af	=	1.00E-01	m2
Interior Height of building	R_h	=	2.44E+00	m
Volume of building	V	=	2.44E+00	m3
Exchange rate of air	E	=	8.30E-01	exchanges/hr
Ventilation rate	Q	=	2.03E+00	m3/hr
Indoor air component	C_I	=	1.70E-01	mg/m3
B. OUTDOOR AIR COMPONENT				
Downwind contamination length	L	=	0.00E+00	m
Wind speed	u	=	1.60E+04	m/hr
Height of building openings (or height of breathing zone)	h	=	2.00E+00	m
Outdoor air component	C_o	=	0.00E+00	mg/m3
C. TOTAL INDOOR AIR CONCENTRATION	C_t	=	1.70E-01	mg/m3

EXPOSURE SCENARIO

Body weight	BW	=	7.00E+01	kg
Inhalation rate	IR	=	2.00E+01	m3/day
Exposure duration	ED	=	7.00E+01	yrs
Hours per day	conversion		2.40E+01	hr/day
Exposure time	ET	=	1.00E+00	hr/24 hours
Days per week	conversion		7.00E+00	days/week
Weeks per year	conversion		5.00E+01	weeks/yr
Exposure frequency	EF	=	3.50E+02	days/yr
Averaging Time (carc. risk)	AT	=	2.56E+04	days
Averaging Time (non-carc. risk)	AT	=	2.56E+04	days
Chemical Intake (carc. risk)	IT_c	=	4.66E-02	mg/kg-day
Chemical Intake (non-carc. risk)	IT_{nc}	=	4.66E-02	mg/kg-day

NON-CARCINOGENIC RISK (Chronic Risk)

Chemical Intake (non-carc. risk)	IT_{nc}	=	4.66E-02	mg/kg-day
Reference dose	RfD	=	1.70E-03	mg/kg-day
Hazard Index	HI	=	2.74E+01	

CARCINOGENIC RISK

Chemical Intake (carc. risk)	IT_c	=	4.66E-02	mg/kg-day
Slope factor (potency)	SF	=	1.00E-01	1/(mg/kg-day)
Cancer Risk	Risk	=	4.66E-03	